# SAROS

## PAPER 6: REHABILITATION
State of the Aggregate Resource in Ontario Study

Prepared for:
Ontario Ministry of Natural Resources

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Prepared by:
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SAVANTA

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Skelton Brumwell and Associates Inc. and Savanta Inc. are pleased to submit this report – Paper 6: Rehabilitation – completed as part of the MNR's State of the Aggregate Resource in Ontario Study (SAROS). The objective of SAROS study is to gain a better understanding of aggregate resource management in Ontario through the completion of six separate papers focused on: consumption and demand, future availability and alternatives, value, recycling and reuse, reserves in existing operations, and rehabilitation.

This Report addresses Rehabilitation, with the intention of providing insight into the status of rehabilitation in Ontario, including actual assessments of a sample study, and review of public expectations an examination of current and emerging techniques and technologies around rehabilitation and a review of global applications of rehabilitation.

Yours truly,

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# SAROS PAPER 6: REHABILITATION
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# SAROS PAPER 6: REHABILITATION
# EXECUTIVE SUMMARY

This report is one of six studies completed on behalf of the Province of Ontario in 2009, in a broad effort to better define the State of the Aggregate Resources in Ontario. The six papers focus on demand, availability, economics, alternatives, recycling/reuse, supply and rehabilitation. Specifically, this Report addresses Rehabilitation, with the intention of providing insight into the status of rehabilitation in Ontario, including field assessments from surrendered and active sites, a review of public expectations, an examination of current and emerging techniques and technologies around rehabilitation and a review of global applications of rehabilitation.

This report addresses 9 separate tasks identified within the Terms of Reference:

1. Review of 50 licences for effectiveness of progressive rehabilitation in the context of site specific healthy ecosystem and healthy community objectives;
2. Review of 50 surrendered licences and list range of after uses;
3. Comment on public expectations related to amount, timing and quality of rehabilitation;
4. Provide a list of opportunities to use rehabilitated aggregate sites to achieve broader healthy community objectives;
5. Discuss the opportunities for comprehensive rehabilitation plans and investigate the opportunities and barriers of the concept both from a resource utilization and integrated rehabilitation viewpoint;
6. Review current science recommendations for pit and quarry rehabilitation in Ontario and how they could support other initiatives;
7. Compare and contrast the differences in rehabilitation methodologies for quarries vs. pits;
8. Provide a global scan of rehabilitation technologies and applications; and
9. Undertake a global scan of alternative after uses of aggregate pits and quarries.

These tasks are generally addressed as separate chapters, with the exception of Task 6 and 7 that are addressed comprehensively under Chapter 6.

The scope of policies, legislation, and programs that directly or indirectly influence the rehabilitation of pits and quarries in Ontario is substantial, as outlined in Chapter 2. The legislation and policies that apply to aggregate extraction and rehabilitation are in effect to ensure that aggregate extraction is an interim land use and rehabilitation is carried out to return the lands to the previous use, or one that is compatible with adjacent land uses. These provide an important framework to guide the implementation of rehabilitation of pits and quarries. The results of the research conducted as part of Paper 6: Rehabilitation suggests that there is less of a need to modify these existing legislation, policies, and guidelines than to work with these and additional supporting tools to help to realize the full potential of rehabilitation programs. Specific to the Aggregate Resources Act (ARA), for example, it is clear that its implementation would benefit from the development of comprehensive best practices guidance document(s) and forums tailored to respond to the information needs of producers and Aggregate Resource Officers (ARO).

Comments emerging out of Chapter 3 – *Public Expectations of Rehabilitation (Task 3)* - were helpful in understanding key concerns and perceptions. Generally speaking, some common sentiments expressed by these contacts, included: a lack of visible progress towards rehabilitated sites; delays in rehabilitation and a lack of provincial enforcement (and a shortage of staff resources); limited evidence of successful rehabilitation beyond a few commonly referred to showcase examples; and a lack of information about rehabilitation reaching members of the public and operators to help them to understand and implement rehabilitation on their sites. Comments were provided around the potential need to revisit existing legislative and policy tools; more comments were offered regarding the need to work more diligently to provide incentive and recognition mechanisms to achieve more significant advancements in rehabilitation.

Additional feedback from interviewees centered on the need for additional policies centered on establishing time limits associated with permitting, maximum disturbed areas, and strengthening of rehabilitation requirements. A review of these comments in the context of the other chapters suggests that some of the opinions can be substantiated while others are largely a result of limited outreach and education. Some of the recommendations emerging from the other chapters, such as improved documentation of surrendered licences and targeted research that responds to identified knowledge gaps, will at least partly serve to address these criticisms.

Chapter 4 – *Review of Progressive Rehabilitation on Licenced Pits and Quarries (Task 1)* - summarizes the outcome of the assessment of 50 licenced sites, assessing those sites that have initiated rehabilitation. Overall, it was found that 58% of sites had been subject to some progressive rehabilitation; 40% had not yet initiated progressive rehabilitation (one denied access so was not assessed). It is important to note that it was not within the scope of this study to investigate the reasons why progressive rehabilitation had not been initiated, nor to assess compliance issues. However, it appears that where rehabilitation has been initiated, they are generally fulfilling the requirements of the site plans. From some more qualitative observations and review of data collected, there seems to be a further pattern that suggests that more advanced and complex rehabilitation is being performed by mid to large sized producers and less so by the smaller site operators/owners. What is also apparent in the review of sites under progressive rehabilitation is that there are opportunities to improve some of the techniques and approaches to rehabilitation to better achieve certain end land use objectives and to optimize the extent to which rehabilitated sites might contribute to healthy community and healthy ecosystem objectives.

Chapter 5 – *Review of Surrendered Licences (Task 2)* - determined that the surrendered sites included a wide range of land uses, with the majority being either agriculture, open space, or recreational, and that they were generally well integrated into the surrounding landscape. The existing land uses are not necessarily the same as the proposed end uses identified on the Site Plans, as the proposed end uses are sometimes identified 20 or more years ago at the time that the site was licenced. In general, the land uses observed on the surrendered sites were compatible with the surrounding area and would not be identified as a former pit or quarry to the general public. It was noted that MNR documentation of surrendered licences is inconsistent and in many instances incomplete. In order to fully capture the data emerging out of the rehabilitation of surrendered sites to allow for monitoring trends at both the site-specific and landscape level, as well as implement and maintain a thorough historical record of licenced properties, it is recommended that information be compiled and entered into a database by MNR as part of the surrendering process. The database established for this project could be used as a start.

Chapter 6 - *Current Science and Methodology for Pit and Quarry Rehabilitation (Tasks 6 and 7)* - examined the extent to which rehabilitated pits and quarries might contribute to broader provincial objectives in light of current science and policy recommendations and in the context of emerging science recommendations related to the rehabilitation of disturbed ecosystems. The concept of rehabilitation can be separated into progressive and final rehabilitation. Progressive rehabilitation refers to rehabilitation that is initiated in depleted areas of the pit or quarry, while extraction continues in other areas. Final rehabilitation is the process of completing the last stages of progressive rehabilitation (such as the removal of a processing plant) and development of the final end use. There is a benefit to considering the establishment of a core group of experts and innovators, focused on advancing the science and practice associated with rehabilitation. Other suggestions offered in this report relate to the importance of policy leadership and communication of research inside the MNR Aggregate & Petroleum Resources Section and relationships with some relevant programming at local colleges and universities.

Chapter 7 – *Opportunities for Rehabilitated Sites to Achieve Broader Healthy Community Objectives (Task 4)* - seeks to identify the extent to which rehabilitated pits and quarries might contribute to '*healthy community*' objectives. Key attributes associated with the socio-economic and ecological parameters associated with '*healthy communities*' were first identified and further correlated to either Task 2 (rehabilitated) sites and/or other case studies. It is reasonable to observe from this study that the degree of contribution to healthy communities can be optimized through: a careful review and consideration of these attributes during the planning for end uses and throughout the life of extraction; consideration of these attributes in terms of the opportunity to meet multiple objectives; and consideration of objectives across a specific geographic area, terrain, watershed/subwatershed and political jurisdictions.

Chapter 8 – *Comprehensive Rehabilitation Plans (Task 5)* - delves into the concept of Comprehensive Site Plans drawing from three case studies, and concludes that both incentives and a clear planning process are critical to ensuring success. Associated with this is a need for agencies to work to ensure a streamlined and consistent review process and also to maximize opportunities for public engagement, all of which will contribute to a greater willingness of stakeholders to overlook higher temporal and financial costs in favour of longer-term benefits associated with these types of innovative endeavours.

Chapter 9 – *Rehabilitation Technologies and Applications: A Global Scan (Task 8) - outlines* rehabilitation technologies, and highlights a broad range of techniques and results. Similar to the recommendations emerging from chapters 7 and 8, chapter 9 emphasizes the need for comprehensive discussions related to rehabilitation goals early in the process. As with the findings of chapters 4 and 6, some rehabilitation techniques are 'tried and true' and are generally found to yield acceptable and predictable results, while others may necessitate additional research to ensure that they do not result in unforeseen and/or undesirable side effects. Conditions resulting from extraction activities may necessitate the creation of novel ecosystems by virtue of their biophysical attributes, but key to the consideration and success of any end land use will be tailoring it to site-specific and landscape level socio-economic and ecological parameters.

Chapter 10 - *Alternative After Uses of Pits and Quarries: A Global Scan (Task 9)* - focuses on a global scan of after uses of rehabilitated pits and quarries. The degree of success was found to be directly linked to the findings of Chapters 6 and 9, in terms of working to accommodate site-specific environmental features with modifications aimed at realizing the full potential of desired end land uses. Rehabilitation efforts in the United Kingdom emerged as being particularly exemplary, and can be at least partly attributed to widespread promotion and acknowledgement of high quality efforts, innovative partnerships between industries, non-government organizations, and in some cases research institutions, and recognition of potential complementary relationship between human needs and nature conservation. This leadership and research is likely in large part due to the significantly higher per tonne fee collected through their Aggregates Levy. Rehabilitation efforts in Ontario will meet with more success if the full range of possible land uses is considered, and if networks of sites are considered simultaneously at the landscape level.

This report contains many recommendations for consideration. Most sections of the report include specific subsections containing detailed recommendations. In addition they are attached as an appendix to this executive summary. The following are the main summary observations and recommendations emerging out of the 9 Tasks undertaken in fulfillment of the requirements of Paper 6: Rehabilitation:

1. Additional funding and support of the Aggregate Resources Program within the MNR would enable greater assistance and education for operators in their progressive and final rehabilitation efforts. Further, a rehabilitation specialist specific to the aggregates program could be a primary contact for Aggregate Resources Officers and operators, disseminate science and global research to the operators and ARO's, and make information on rehabilitation available to the public through newsletters, annual reports, awards, website, etc.

2. Existing policies and legislations, including the ARA, are generally well suited to prescribing broad-level approaches to the rehabilitation of pits and quarries in Ontario. However, the development of detailed best practices guidance documents, updated

regularly, and associated forums that are suited to the needs of small to large scale producers will facilitate the implementation of key policies and legislation, and ultimately translate to higher quality and more timely rehabilitation.

3. In order to improve rehabilitation in terms of quantity, quality and timing, there should be investigation by the province of potential incentives for producers. Many examples were cited by public contacts that would provide ideas for consideration.

4. The absence of data related to the quantity and quality of rehabilitation being undertaken in Ontario in a readily useable format, opens the existing state of rehabilitation up to criticism. Improved documentation and reporting of surrendered licences and rehabilitation in Ontario will provide a better basis for evaluating trends over time, and for responding in a substantive manner to criticisms.

5. Public awareness and understanding of processes and policies related to aggregate extraction and rehabilitation is lacking. There is a need for increased education, outreach and dialogue between the industry, the public, provincial agencies and ENGO's.

6. The relationship between the aggregate industry and non-governmental organizations in Ontario has tended to be relatively non-collaborative. This contrasts with many of the case studies reviewed in the global scans. Internationally, there are examples of partnerships between industry, non-government and government organizations, and research institutions aimed at better balancing the demands for aggregate materials with other socio-economic and ecological considerations. This has translated to some outstanding examples at the planning and implementation stage of rehabilitated pits and quarries that successfully meet a broad range of local and regional objectives. There are many opportunities to expand the scope and breadth of industry-ENGO relationships in Ontario to achieve broader landscape level objectives. The industry and ENGO's are encouraged to continue their collaboration towards these and other goals.

7. Rehabilitated sites have not fully optimized the potential for contribution to broader provincial objectives for healthy communities. Improved collaborative decision-making between provincial and municipal governments that maximizes cumulative benefits

associated with the rehabilitation of multiple sites will serve to better achieve landscape level gains.

8. Aggregate producers are largely adhering to current science recommendations and to the rehabilitation specifications set out in site plans. It appears that most innovations and substantial ongoing efforts are being accomplished by the larger and medium-sized producers.

9. There is a need to better integrate emerging science recommendations into the rehabilitation of pits and quarries, and to ensure that the research, in turn, responds to identified knowledge gaps. Encouraging innovation and flexibility in approaches to the rehabilitation of aggregate pits and quarries will foster advances in the understanding of ecosystem processes. Similarly, drawing not only from novel approaches within the province but also from other jurisdictions will continue to expand the knowledge base. The establishment of a core group of experts, (perhaps building on the outcome of the October 14, 2009 workshop) focused on fully integrating theoretical with applied research, is well positions to respond to knowledge gaps and will serve to better respond to the needs of both aggregate producers and Aggregate Resource Officers.

In summary, it is apparent that rehabilitation is occurring at many sites in Ontario as intended, with most efforts being of a prescriptive nature. The earliest rehabilitation efforts were relatively simple, with end use targets being a return to some level of productive capacity for farming or forestry. Depth to water table, site preparation and soil handling were key considerations in those works. The natural and/or open space landscapes initiated have evolved with many providing a high level of biodiversity. Traditional rehabilitation techniques (e.g., site levelling and homogeneity in micro-topography) have tended to limit the diversity and productivity of ecological outcomes. Some examples are presented in this report where more innovative thinking and techniques (e.g., soil amendments, broader landscape level planning, etc) will contribute to more effective end rehabilitation results.

Just as there is a need to update some of the current science recommendations to better reflect today's standards, there is a need for greater flexibility in some of the planning and policy tools, including rehabilitation site plans. There are specific barriers to the advancement of best rehabilitation practices, some of which are associated with policies being incompatible with newer science. For example, the current approaches and accepted practices around depth of soil and location of water table and around the treatment of rehabilitated slopes and cliff faces would benefit from being reviewed.

Critical to the above-noted recommendations will be the compilation and dissemination of information to the broader industry, including producers and Aggregate Resource Officers, ENGOs, and the general public and the acceptance of innovative and novel partnerships by the stakeholders at all levels.

APPENDIX A

PAPER 6: REHABILITATION

CONSOLIDATED RECOMMENDATIONS

***TASK 1 (CHAPTER 4) - Review of 50 licences for effectiveness of progressive rehabilitation in the context of site specific healthy ecosystem and healthy community objectives.***

1. Forty percent of the sample sites have not initiated progressive rehabilitation. It was beyond the scope of this study to assess whether there is an opportunity to initiate rehabilitation on these sites. Therefore, it is recommended that the Aggregate Resources Officer meet with these operators to determine what, if any opportunities exist to start progressive rehabilitation.

2. It was evident through the field visits with operators that they are lacking information on how to initiate and develop quality rehabilitation programs for their properties. As an immediate step, MNR should forward all available information on rehabilitation to all licensees (e.g. existing MNR papers/newsletters, MNR publications and other references within this report).

3. As recommended in other sections of this report, it would be useful to have a Rehabilitation Specialist within MNR Aggregates and Petroleum Section that could coordinate these activities as well as other needed rehabilitation initiatives.

4. The results of the floristic inventories at the 24 sites under rehabilitation to natural heritage/open space indicate the presence of a high number of non-native and in many cases invasive species. This combined with the site operator/owner interviews suggest that there is a reliance on the use of commercial seed mixes in the approaches to rehabilitation of aggregate sites. There is a need for additional guidance, outreach and education to ensure that more appropriate native seed mixes are used. Associated with this is a need for applied research into the types and sequencing of native seed mixes to maximize successful rehabilitation to natural heritage/open space land uses.

5. The prevailing approach of limiting rehabilitation to grading and seeding at sites, in the absence of follow-up plantings with native species (and potentially soil amendments) will not contribute to successful achievement of ‘healthy ecosystems’ in the longer term. It is recommended that operator’s be educated and encouraged to put their money and efforts into more effective rehabilitation (e.g. variable grading, natural seed mixes).

6. The incidental observations of wildlife suggest revealed that some of these sites provide habitat for a certain number of species that are relatively rare or at some level of decline in the province. There appear to be opportunities and an interest with some producers to create a greater diversity of habitat that will maximize benefits to wildlife; however, greater outreach and education and technical guidance is required.

7. The results of the soil sample analysis indicated that they are bacterial-dominated and that nutrient cycling is fast and open. Applied research aimed at soil amendments to increase carbon:nitrogen ratios, organic matter, and overall fungal diversity is recommended.

***TASK 2 (CHAPTER 5) - Review of 50 surrendered (fully rehabilitated) licences and list range of after uses.***

1. Prior to licence surrender, MNR complete an information sheet to be entered into the database started by this project. The database can be used to collect data on surrendered licences for the compilation of statistics on after rehabilitated land area and after uses, and to facilitate ongoing research on rehabilitation.

***TASK 3 (CHAPTER 3) - Comment on public expectations related to amount, timing and quality of rehabilitation.***

Text in shaded boxes reflect specific comments from contacts. Other text are recommendations arising from this research.

## 1. Suggestions to Increase Amount, Timing and Quality of Rehabilitation

i) Recognition Program

There is a certain prestige with being recognized for the achievement of excellence in the field of rehabilitation. The industry association, OSSGA, has a series of achievement awards for operations and rehabilitation that are presented to selected producer members of OSSGA on an annual basis. This program has served an important function in establishing benchmarks for excellence especially within the OSSGA membership base. Building upon this program, it would be appropriate to consider the establishment of a province-wide recognition program that captures all industry members including those within and outside of OSSGA. Ideally this program would be implemented and maintained by the province, in association with a number of collaborating or partnering groups. A recognition program would be a positive element to complement an effective enforcement monitoring program for progressive rehabilitation.

ii) Information on Rehabilitation Must Reach Operators

MNR should provide more information to operators on when and how they can undertake progressive rehabilitation. This would be effectively facilitated through an annual site visit, where the Inspector reviews the operation and ensures the operator has been appropriately implementing progressive rehabilitation.

iii) Companies, Public and Agencies Benefit from Open-Door Policy

Some leading companies have opened their doors to the public and agencies in the form of Community Open Houses. These are beneficial in terms of maintaining and enhancing community relationships. Some companies have extended this approach and are inviting agencies to review annual monitoring reports and discuss aspects of the operation that are of interest.

iv) Incentives

Without exception, all respondents agreed that it is necessary to establish an incentive program for the operator, in order to obtain faster and better rehabilitation. It was recognized that incentives can play a role to increase rehabilitation in addition to the enforcement requirement and the desire to do the right thing. Examples for incentives put forward include:

**Examples of Incentives**

- Some form of rebate program (respondents cited apparent success of the recent "Home Improvement Rebate");
- More innovative tax incentives as land is rehabilitated; (e.g. Currently rehabilitated land is assessed at a lower rate than disturbed land. If it were assessed lower than the pre-extraction land there would be a further financial incentive to rehabilitate as quickly as possible and keep disturbed area to a minimum.)
- Development of Certification Standards (e.g. Forestry Industry);
- Implementation of Best Management Practices; and
- An operator should have to earn the right to continue extraction (i.e. a social licence to operate).

v) MNR Needs to Encourage More Rehabilitation

MNR needs to increase efforts to educate those operators that need assistance with rehabilitation. There is information available (see Tasks 6 & 7 reports and associated references), but it is not necessarily reaching the producers in a useful manner. MNR should consider bulletins or annual reports that would assist operators. Furthermore, respondents noted that MNR needs to enforce the existing legislation. Some respondents noted that there needs to be a will to conform on behalf of both MNR and the industry.

Although a valuable position exists within the Science and Research Branch of MNR for rehabilitation, there is no parallel position in the Aggregate & Petroleum Resources Section. Up until the 1990's there was a "Rehabilitation Specialist" in this section that was a "go to" person for the Aggregate Resources Officers and was responsible for policy development on rehabilitation. If such a position were re-instated (either with current Policy Advisors, or a new position), there would be an information source for field staff, as well as an avenue to produce annual reports, analyze rehabilitation costs, publish newsletters, recognize good rehabilitation practices and provide educational updates, review licence applications to ensure practical and feasible rehabilitation, and field assistance. This would not only provide new information to operators and field staff, but it would assist in disseminating MNR's on-going research through TOARC and the Science and Research Branch

vi) Important MNR Research Requires More Dissemination

There is research being undertaken by both TOARC and MNR in the Wildlife Research and Development Section; however this information is not necessarily reaching the Aggregate Resources Officers, and ultimately the operators, in a practical manner. There needs to be more communication between TOARC and key MNR groups with a focus on getting practical and helpful information to the pit and quarry operators.

vii) Involve More People – Openness and Accountability

Currently, rehabilitation is the responsibility of the MNR and operators. Some respondents perceive this to be too tight a relationship, and point towards the potential benefit of including other agencies. Interestingly, it was also suggested that operators and MNR inspectors are not communicating effectively enough. With an increase in openness and accountability there is an opportunity to educate more people on the status of progressive rehabilitation.

viii) More Time and Resources to Research

More time and resources (both government and industry) need to be invested to better understand what rehabilitation techniques work and how they are suited to certain areas. This includes allowing operators more flexibility in terms of research and innovation on their properties. This has been resisted in some MNR districts.

ix) Involve University Students and Broader Academia

Some respondents noted that it is important to get students involved as they bring new ideas to the industry and they represent the future of pit and quarry rehabilitation. Involvement with academia is an opportunity to have research carried out and results published for broader integration with government programs.

x) Partnerships

In some cases, partnerships with local groups could enhance rehabilitation. There are a wide range of groups with specific expertise such as Tallgrass Ontario, Nature Conservancy of Canada, Ontario Invasive Plants Council, Ontario Federation of Agriculture, recovery teams for species at risk, etc. that would be well positioned to work with aggregate producers to assist in rehabilitation if the end result helped to further their individual mandates.

Some respondents are interested in providing increased access for local and interest groups (e.g. ORM, land trusts, etc.) for assuming rehabilitation requirements under agreements.

xi) Eliminate Punitive Measures Which can Discourage Successful Rehabilitation

Some producers have experienced designations being added to their properties, based on rehabilitation they have undertaken (e.g. tree planting resulting in significant woodland designations). Similarly, there is concern on behalf of some producers that they may be creating habitat that attracts Species at Risk. These positive outcomes should not be detrimental to the continued operation of the site, and should be carefully considered in terms of consequences for the end use after the licence is surrendered.

xii) <u>Comprehensive Rehabilitation Plans</u>

In order to increase the quality of final rehabilitation in areas where there are multiple licences on a deposit, comprehensive rehabilitation plans are necessary.

xiii) <u>Time Periods for Extraction</u>

Some respondents felt that a pit that has been left open for an extended period of time (e.g. 20 years) with no extraction, should be rehabilitated and the licence should be surrendered. This was raised as a particular sensitivity in some areas, where sites have been seen as eye sores for many years. Respondents stated that there should be a time limit for extraction, after which the public and producer know the site must be rehabilitated.

xiv) <u>Site Specific Increased Tonnages to Assist in Efficiently Consuming Resources</u>

Some sites are not rehabilitated because they have small amounts of material left. One suggestion is that the MNR could offer an increase in tonnage (where tonnages are low) so that the material could be removed all at once, allowing final rehabilitation to occur sooner.

xv) <u>Maximum Area Disturbed on the Site Plan</u>

There could be limits put on the site plan as to a maximum disturbed area. This should be limited to one area, so there are not multiple areas open at one time. Some respondents noted that this has occurred in the Greenbelt, through the Greenbelt Plan, but could be introduced province-wide through changes to Provincial Standards.

xvi) <u>Strengthening the Rehabilitation Requirements of the ARA</u>

One of the recommendations of the Report by The Pembina Institute (Rebalancing the Load, January 2005) states that “The requirements under the Aggregate Resource Act for the rehabilitation of pits and quarries should be strengthened. The expansion of existing operations should only be permitted on the basis of substantial progress on the rehabilitation of the disturbed area within the existing licensed area (generally no less than 50 % of rehabilitation of the disturbed area). In the meantime, the enforcement of the existing rehabilitation provisions of the Act should be significantly strengthened."

This has been supported by a public request that the ARA be enforced and modified to provide rehabilitation in an open and accountable manner. Specifically, it was suggested amendments are required so that the ARA becomes effective in ensuring that rehabilitation actually takes place. It was felt this would require additional revisions to regulations and policies to support the clear intention of accomplishing progressive and final rehabilitation of the ARA (Holt, R, and James, E. 2003).

**2. Public Education on Rehabilitation**

i) Most contacts felt there was a need to educate the public on rehabilitation efforts for pits and quarries. However, there was a caution that some forms of education could be detrimental. The public could see efforts as "green washing" if the industry promotes themselves as excelling at rehabilitation. The following is a summary of suggestions and ideas as to how to increase public education.

<u>Suggestions for Increased Public Education</u>

- Open Houses have been used by companies to open their doors and meet with neighbours. More attention to progressive rehabilitation would be beneficial and these Open Houses could be used to discuss what has worked and what has been learned in terms of preferred rehabilitation techniques.
- Use of Citizens Advisory Committees can be effective tools for education, sharing of information and listening to concerns.
- The Industry, Conservation Authorities, Municipalities, School Boards and TOARC can each contribute to communicating about successful rehabilitation projects. There are some fine examples of progressive rehabilitation that should be shared. Conservation Authorities and others could assist with programming and signage and offer an opportunity to partner in educational opportunities. Pits offer an opportunity to serve as outdoor classrooms.
- Tours can be an excellent way to educate the public on pit and quarry operations and rehabilitation. They can provide more information than an Open House, but some respondents suggested that tours are not always balanced.

Suggestions for Increased Public Education

- Signage may help educate the community. For instance, if a pit is used sporadically for local road jobs, a sign could be posted to describe the use of the material and the frequency. The public would better understand the reason for pits being left "fallow".
- There needs to be more education on operations and rehabilitation as the two are (or should be) connected. Education should contribute more to an understanding of rehabilitation. It is also important to understand what was learned from rehabilitation efforts (e.g. was the end result different than what was planned, what would be done differently, etc.), so that efforts can continue to get real gains.

### 3. Opportunities for Partnering in Rehabilitation

i) It was agreed by interviewees that there is an important role for engaging/partnering with the public and/or groups in rehabilitation. It was generally felt that if people are engaged and educated about a site, they will want to be involved with its development. Community support can also assist in obtaining funding for projects. Finally, many respondents noted that the local community knows the area. With their input, the rehabilitation of each site can be optimized.

ii) It was recognized that some pits and quarries have greater opportunities than others for partnering. For instance, an agricultural field, returned to agriculture, does not offer as much potential. However, if the land becomes a part of the community (e.g. recreational pond, or open space surrounded by residential housing), then the public might offer some additional perspectives regarding rehabilitation (e.g. shorelines, access, etc.).

Suggested Engagement Activities

- Developing manuals;
- Development of rehabilitation programs for a pit or quarry, or portions of the site;
- Rehabilitation tours;
- Discussions as to what rehabilitation will entail;

Suggested Engagement Activities

- Discussion of potential conflicts and ways to remedy them;
- Seed collection and nurseries; and
- Practical rehabilitation – true and long term (e.g. developing amphibian habitat)

Suggested Partners

- ENGO's (environmental non-governmental organizations) such as Ducks Unlimited, Nature Conservancy of Canada, Bird Studies Canada, Tallgrass Ontario, recovery teams for species at risk, etc.;
- Interested community members, that could include environmental programs, research groups and birders, as well as more non-traditional groups such as book clubs or road maintenance groups;
- The Aggregate Forum (a group of ENGO's and Aggregate Industry representatives);
- Universities and other research institutions;
- Industry groups (OSSGA, CLRA, TOARC);
- MNR;
- Municipalities;
- Conservation Authorities;
- School classrooms;
- Other provincial ministries (e.g. MMAH staff play a significant role in developing policy to protect land for extraction, yet they are not as informed about the operating pits and quarries, including their rehabilitation); and
- Service Clubs (e.g. Boy Scouts). The scouting movement has a long association with many pit and quarry operators and has contributed to tree planting on many sites every year.

iv) Establishing and maintaining these partners takes time, effort and money, but according to many contacts interviewed, it must be done in order to build relationships and educate one another on interests and goals.

4. **Identification and Record Keeping of Rehabilitated Pits and Quarries**

i) In the review of the 50 surrendered licences, it was apparent that the final documentation of the site, including contact names and photographs varied from district to district. MNR policy is clear on the steps to be taken for surrender of a licence relative to compliance with the ARA, however, there is no additional requirement for documentation of the life of the pit or quarry and subsequent rehabilitation, and associated record keeping on a data base. As the mandate for Pits and Quarries falls under MNR, if they are not keeping track of this information, no one is. It would be relatively simple for Aggregate Resources Officers to fill out a form as part of the surrendering process, and have this information added to the data base established by this study. It was widely recognized by the contacts that there should be an improved historical record kept of when the site was operated, who operated it, what the material was used for and how much was extracted, and when it was rehabilitated. Further, there was a suggestion that it should be publicly available on a database. If the database is not continued for this purpose, other existing documents could include this information (e.g. MNR Land Use Policy or District Land Use Guideline mapping, Official Plans, Trail Guides, etc.)

ii) There should be a complete data record from MNR at the time of licence surrender (including the development of a data collection form on the history of the site) and regular updating of a data base to historically document the sites that have been rehabilitated. It is imperative that there be a permanent record keeping of the extractive sites, accessible by the public, otherwise these sites will disappear, along with the history of their contribution to local communities.

iii) In addition, there should be further discussion as to whether recognition is provided for quality rehabilitation. This includes signage on properties, awards issued by governments or ENGO's, and publications.

5. **Industry Involvement**

i) In the last year there has been development of a group of Industry members, OSSGA and ENGO's working together in positive discussions about aggregate management within the province of Ontario. These industry and ENGO collaborative discussions are a positive step and one that would be beneficial to continue to build upon. Certainly many of the recommendations within this report can be met through this kind of collaboration.

***TASK 4 (CHAPTER 7) - Provide a list of opportunities to use rehabilitated aggregate sites to achieve broader healthy community objectives.***

1. Rehabilitated pits and quarries have significant potential to meet Healthy Community objectives. Many sites associated with Chapter 5 achieve important natural environment, agricultural, and open space objectives. A smaller number contribute to objectives related to economic and development aspects of healthy communities.

   It is reasonable to observe from this study that the degree of contribution to healthy communities can be optimized through:

   i) A careful review and consideration of these attributes during the planning of end uses.

   ii) Consideration of these attributes in terms of the opportunity to meet multiple objectives.

   iii) Consideration of objectives across a specific geographic area, terrain, watershed/subwatershed and political jurisdictions.

2. Comprehensive planning and decision-making in a Healthy Communities context will lead to enhanced potential and realised opportunities for rehabilitated aggregate sites to achieving a range of socio-economic and ecological objectives that will benefit the landscape and its inhabitants.

***TASK5 (CHAPTER 8) - Discuss the opportunities for comprehensive rehabilitation plans and investigate the opportunities and barriers of the concept both from a resource utilization and integrated rehabilitation viewpoint.***

1. Municipal and Land Use plans ( such as Official Plans, the ORM Plan and NEP) with large resource areas should give consideration to the preferred after uses, including the designation of after uses and definition of special policy areas, during the routine process of Plan updates. This would be in addition to the licensee's requirement under the ARA to identify the proposed final land use, and could assist in establishing goals.

2. Municipalities, through updates of their zoning by-law, should include a clause which provides for side and rear yard setbacks to be automatically reduced to zero along a common licenced boundary.

3. Municipal Official Plans, during the routine process of Plan updates, should have policy to encourage extraction of common setbacks between licences.

4. Planning for "greenfield" areas as defined by the Growth Plan for the Greater Golden Horseshoe under the Places to Grow Act should include consideration for Comprehensive Rehabilitation Plans.

5. Ministry of Natural Resources should develop a Policy and Procedure to encourage the harmonization of two or more adjacent operations through the mutual extraction of common boundary setbacks and creation of a common after use plan, under the site plan amendment process

6. Where multiple sites exist abutting one another, especially adjacent to a road allowance, MNR and the municipality should attempt to find a common approvals process. The producers will have access to additional reserves, so they should be interested in participating, recognizing it is a 'give and take' process.

7. Providing an opportunity for public engagement would be beneficial. Once the public realizes they can be a part of something that will change the landscape to meet their goals,

they may be willing to participate. The municipality and MNR should be promoting and supporting these initiatives, as they implement provincial policy (PPS).

8. Comprehensive Rehabilitation Plans should be considered as early as possible. Once in place, they provide certainty to both producers and local residents. This could help reduce the tensions that have increased around applications.

***TASK 6 (CHAPTER 6) - Review current science recommendations for pit and quarry rehabilitation in Ontario and how they could support other initiatives. AND TASK 7 (CHAPTER 6) - Compare and contrast the differences in rehabilitation methodologies for quarries vs. pits.***

1. Encourage the establishment of a Scientific Review Panel or Committee with appropriate scientific and policy expertise. That team would have an ongoing role of ensuring current scientific thinking is vetted and provided to the province on a regular basis. This might best be accommodated within existing aggregate and/or scientific units of the MNR. It could be further facilitated by the creation of a research and best practices coordination position (Rehabilitation Specialist) within the Aggregates program.

2. Develop an annual research list in collaboration with TOARC to ensure that the research activities are optimized and to ensure the results are communicated broadly. Ideally, the industry and Aggregate Resources Officers would provide input into this list so that the most critical needs are met first, with additional feedback from the broader research community to allow for exchange of ideas and concepts.

3. Build upon existing relationships with Academia and collaborate to ensure existing specialty programs address restoration capacity building (e.g., Sir Sandford Fleming College, University of Trent, Niagara College).

4. Continue to develop Best Management Practices and associated guidance documents for industry.

5. Continue to examine the policies and accepted practices around soil requirements in rehabilitation. There are many ecological niche communities that can be established effectively with limited soils. Consider the appropriateness of increased flexibility around soils (e.g., aesthetic berms) where it might not be helpful to the end use and rehabilitation process.

6. Encourage innovation and the creation/retention of interesting features (e.g., alvars, fens, cliff and bank faces, floating islands, sheltered cliff perches, etc.).

7. There is currently a disconnect for owners/operators between the conservation and/or enhancement of habitat for Species at Risk and the retention of their right to extract licenced material under the ARA. While the aggregate industry has the land base, and access to proven scientific and technical methodologies to create and protect habitat, the successful creation, enhancement, and protection of habitat to benefit Species at Risk could curtail or shut down the operation. This should be resolved between Ministry programs.

8. Engage in discussions with Ontario’s landscape nursery and seed industries to foster a dialogue that will lead to more commercially available endemic plant materials and preferred seed mixes.

9. Enable partnerships to occur between producers and stakeholders without penalty or hardship to either (e.g. public use of licenced lands for trails).

10. Consider opportunities for the development of funding mechanisms to assist in the delivery of recommended programming. This final recommendation is one of the most important of this study. Financial resources will need to be put in place in order to see the real change that is achievable for pits and quarries.

# SAROS PAPER 6 REHABILITATION

# CHAPTER 1
# SAROS PAPER 6: REHABILITATION
# INTRODUCTION

As stated in the Provincial Policy Statement, aggregate extraction and the supply of stone, sand and gravel for the construction industry is recognized as an important component for development and growth in southern Ontario, and maintenance of infrastructure. Understanding where the sources of aggregates exist, planning for appropriate extraction and implementing rehabilitation and/or re-development are necessary to ensure future access to these vital resources for the people of Ontario. These however are not easy tasks particularly given the increasing adversity over aggregate extraction in some rural areas of Ontario.

The Province not only has the responsibility to protect and make available aggregate resources for the long term, but also to ensure that meeting this need is balanced with other cultural and natural heritage land uses. In order to ensure the best planning and management of aggregate resources, current science, new data and information on the resource must be collected (SAROS, Request for Proposals, 2009).

In 1990, the Ministry of Natural Resources (MNR) commissioned a study to conduct a comprehensive technical assessment of the current state of aggregate resources in Southern Ontario. This study was released in 1992, entitled “Aggregate Resources of Southern Ontario - A State of the Resource Study”. The study provided a valuable framework for the development of future provincial and municipal initiatives and policy formulation with respect to aggregate resources of Ontario (State of the Resource Study, 1992). However, much of the information is now out of date. Additionally, new emerging science and government leadership on building strong sustainable communities has changed the context for aggregate resource demand and availability (SAROS RFP, 2009).

Other reports have also been released on Aggregate Resources, including “Rebalancing the Load: The Need for an Aggregates Conservation Strategy for Ontario” by The Pembina Institute, 2005, and more recently “Between Rock and a Hard Place – Understanding the Foundations of Ontario’s Built Future” by the Canadian Urban Institute, undated (released October 2009).

It has been MNR's intent to update their original study, and as the Premier stated in 2007: "*We recognize that more needs to be done on aggregate resource conservation, but that conservation will address only a part of the growing demand for aggregate products. As a key next step to ensure a better understanding of aggregate resources, we will undertake to update key parts of the Aggregate Resources of Southern Ontario – A State of the Resource Study (1992). The Ministry of Natural Resources will work with other ministries and stakeholders to review this new information*." (SAROS, RFP, 2009, letter to the Priorities for Ontario Coalition, Sept. 23, 2007).

In March of 2009, MNR released a Request for Proposals for the Study of Aggregate Resources of Ontario (SAROS), consisting of 6 papers to be completed within 6 months. The study was divided up into 6 individual papers in order to maximize consulting expertise and assist consultants in meeting the tight timeframe. The project manager is Brian Hollingsworth, Policy Officer, Planning, Aggregate & Petroleum Resources Section. The governance structure for the study is supported by two committees: the Advisory Committee and the Technical Expert Panel. The Advisory Committee is made up of leaders of stakeholder organizations, with a role to review the scope of the project, monitor progress, review the consolidated report and provide recommendations back to government. The Technical Expert Panel includes experts from various ministries, aggregate industry associations, academics and environmental stakeholders with specialized knowledge in areas of recycling, rehabilitation, economics, construction, geology, transportation, aggregate planning and management (SAROS, RFP 2009). The role of the Technical Expert Panel is to advise MNR on information received from the consultants, review the reports and provide feedback, and prepare the consolidated report for review by the Advisory Committee.

The objective of the SAROS study is to gain a better understanding of aggregate resource management by gathering current information. The six papers focus on consumption and demand, future availability and alternatives, value, recycling and reuse, reserves in existing operations, and rehabilitation.

Specifically, this Report addresses Rehabilitation, with the intention of providing insight into the status of rehabilitation in Ontario, including actual assessments of a sample study, and review of public expectations and more global applications of science and technology to enhance rehabilitation.

As outlined in the Terms of Reference, Paper 6: Rehabilitation was divided into 9 separate tasks;

1. Review 50 licences for effectiveness of progressive rehabilitation in the context of site specific healthy ecosystem and healthy community objectives (Task 1);
2. Review of 50 surrendered licences and list the range of after uses (Task 2);
3. Comment on public expectations related to amount, timing and quality of rehabilitation;
4. Provide a list of opportunities to use rehabilitated aggregate sites to achieve broader healthy community objectives;
5. Discuss the opportunities for comprehensive rehabilitation plans and investigate the opportunities and barriers of the concept both from a resource utilization and integrated rehabilitation viewpoint;
6. Review current science recommendations for pit and quarry rehabilitation in Ontario and how they could support other initiatives;
7. Compare and contrast the differences in rehabilitation methodologies for quarries vs. pits;
8. Provide a global scan of rehabilitation technologies and applications; and
9. Undertake a global scan of alternative after uses of aggregate pits and quarries.

This report is set up in chapters to address these 9 tasks, with cross referencing and integration of topics. Each chapter introduces the task being reviewed, to tie in directly with the Terms of Reference. Reference to Task 1 and 2 is used consistently throughout the report, identifying the 50 licenced and 50 rehabilitated sites reviewed, respectively (Chapters 4 and 5). For the most part, detailed conclusions and recommendations are found at the end of each chapter, with summation conclusions and recommendations at the end of the report. Appendices have been included at the end of each chapter, and references have been combined for the whole report, and are found in Chapter 12.

There have not been significant changes to on-site rehabilitation requirements for pits and quarries in Ontario since the implementation of the Aggregate Resources Act (ARA) in 1990. This project presents an opportunity to carefully examine the current state and perspective of rehabilitation in Ontario, and compare it with global jurisdictions. The information provided within this report identifies the current thinking around planning and science as it relates to rehabilitation, and makes recommendations for consideration by the province so they can ensure the best planning and management of aggregate resources is carried out.

# CHAPTER 2

# SAROS PAPER 6 REHABILITATION

# LEGISLATIVE AND INDUSTRY CONTEXT

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# 1.0 INTRODUCTION

In Ontario, aggregate extraction and site rehabilitation is governed by a number of Provincial Acts and Plans. The primary regulatory mechanism is the Aggregate Resources Act (ARA) with its associated regulations, and the Provincial Standards which address licensing, operations and rehabilitation. The Provincial Policy Statement (PPS), issued under Section 3 of the Planning Act, provides policy framework relative to matters of provincial interest which include aggregate resources.

Provincial Plans apply to particular areas of the province and provide more specific policies for rehabilitation than the ARA. These Plans have specific enabling legislation and include the Niagara Escarpment Plan, the Oak Ridges Moraine Conservation Plan and the Greenbelt Plan.

The legislation and policies that apply to aggregate extraction and rehabilitation are in effect to ensure that aggregate extraction is an interim land use and rehabilitation is carried out to return the lands to the previous use, or one that is compatible with adjacent land uses. This chapter provides a brief introduction to these documents to establish the legislative framework under which rehabilitation is governed, and must occur. More detailed discussion of specific policy and requirements is included in Chapter 6.

# 2.0 AGGREGATE RESOURCES ACT

The Ministry of Natural Resources is responsible for the management of aggregate resources including sand, gravel and stone under the ARA. The ARA does not apply to the entire province, but only those municipalities designated within the Act. Currently, all of southern Ontario and parts of northern Ontario are designated. A licence is issued for private land, and a permit is issued for Crown land.

The purposes of the Aggregate Resources Act are to:

(a) provide for the management of the aggregate resources of Ontario;

(b) to control and regulate aggregate operations on Crown and private lands;

(c) to require the rehabilitation of land from which aggregate has been excavated; and

(d) to minimize adverse impact on the environment in respect of aggregate operations. (ARA, 1990, Part 1, Section 2.)

## 2.1 Rehabilitation Requirements – Aggregate Resources Act (ARA)

Rehabilitation of pits and quarries has been required since implementation of the Pits and Quarries Control Act (1972). The Aggregate Resources Act requires every licensee and permittee to perform progressive as well as final rehabilitation on the site in accordance with the Act, the regulations, the site plan and the conditions of the licence/permit to the satisfaction of MNR (ARA, 1990). Sites licenced prior to 1990 were required to prepare replacement site plans in compliance with the ARA and the Provincial Standards. Therefore all licences and permits are subject to the requirement for progressive and final rehabilitation.

The following definitions from Section 1 (1) of the ARA are relevant to rehabilitation:

"Progressive Rehabilitation means rehabilitation done sequentially, within a reasonable time, in accordance with this Act, the regulations, the site plans and the conditions of the licence or permit during the period that aggregate is being excavated."

"Final Rehabilitation means rehabilitation in accordance with this Act, the regulations, the site plan and the conditions of the licence or permit performed after the excavation of aggregate and the progressive rehabilitation, if any, have been completed."

"Rehabilitate means to treat land from which aggregate has been excavated so that the use or condition of the land:

a) is restored to its former use or condition, or
b) is changed to another use or condition that is or will be compatible with the use of adjacent land."

Where progressive rehabilitation is not undertaken as required by the site plan, Act or licence, MNR may issue an order to perform progressive or final rehabilitation in accordance with Section 48 (2) of the ARA.

The Aggregate Resources of Ontario Provincial Standards (Provincial Standards) have been developed to support the ARA. They provide standards for site plans, which include the requirements of progressive and final rehabilitation that must be illustrated on site plans. Specifically they require:

- The sequence and direction of progressive rehabilitation;
- Details on how the overburden and topsoil will be used to facilitate progressive rehabilitation;
- The location, design and type of vegetation (e.g. grasses, legumes, shrubs and trees, etc.) that will be established on the site during progressive and final rehabilitation;
- How the slopes (progressive and final) will be established on the excavation faces and the pit/quarry floor;
- Details on how progressive rehabilitation will be conducted in relation to the operational sequences; and
- If proposed, details on the importation of topsoil or inert material to facilitate rehabilitation of the site.

The Provincial Standards also include Operational Standards that specify operational requirements that must be adhered to, unless the site plan specifically provides otherwise, and is approved by the MNR. Operational standards that pertain to rehabilitation include:

- Topsoil must be stripped sequentially prior to aggregate extraction;
- All topsoil or overburden that is stripped during the operation of the site will be stored separately with vegetated stable slopes;
- Adequate vegetation is established and maintained to control erosion of any berm of stockpile of topsoil or overburden;
- Removal of topsoil from the site shall not occur;
- All topsoil or overburden stripped in the operation of the site is used in the rehabilitation of the site;
- Adequate vegetation is established and maintained to control erosion of any topsoil or overburden replaced on the site for rehabilitation purposes;
- When the site is finally rehabilitated, all excavation faces:
    - Of any pit has a slope that is at least three (3) horizontal metres for every vertical metre;
    - Of any quarry has a slope that is a least two (2) horizontal metres for every vertical metre;
- Rehabilitation of the site shall ensure that:

- Adequate drainage and vegetation of the site is provided; and
- Any compaction of the site is alleviated.

## 2.2 MNR Rehabilitation Policies and Procedures Manual

MNR Staff in the Aggregate and Petroleum Resources Section have developed a Policy and Procedure Manual (Manual) that guides the delivery of the Aggregates Program. As stated within the Rehabilitation General Policy A.R. 6.00.00 of the Manual dated March 15, 2006, site plans are the primary driver for defining rehabilitation requirements for licenced and permitted sites. Rehabilitation practices should be determined on a site-specific basis, with consideration of the following:

a) restoration to former use or condition;
b) compatibility with surrounding land uses, including aesthetics;
c) agricultural productivity/soil capability;
d) encouraging biodiversity; and
e) meeting the requirements of the Oak Ridges Moraine Conservation Plan, the Greenbelt Plan, or the Niagara Escarpment Plan.

In addition, an objective for the site plan design is to keep the "disturbed area" to a minimum. In this regard, consideration is to be given to the variability of the resource and the need for adequate area for processing, stockpiling and handling of aggregate, so that there is enough open area for full site operations. (Manual Policy A.R. 6.00.00, March 15, 2006).

Policy A.R. 6.00.00 clarifies that the Provincial Standards provide a minimum expectation for rehabilitation that can be applied to all pits and quarries. Because of the diversity of factors affecting rehabilitation opportunities (topsoil quality and availability, climate, pit vs. quarry, intended after-use) additional standards or enhancements may be added on a site specific basis.

The manual provides additional information that is useful to producers and MNR staff on: rehabilitation to agriculture (recommends 12 months monitoring to verify productivity and soil capability standards have been met); natural regeneration; establishing slopes; cliff faces and pubic safety.

## 2.3 Newly Designated Areas

The ARA provides for designation of new geographic areas (i.e. parts of province not currently designated for aggregate extraction) by the Province. Owners of existing pits and quarries within newly designated areas have the opportunity to apply for a licence under the ARA, a process referred to as “grandfathering”, or they may choose to cease operations. If they choose not to licence their property, any obligation for rehabilitation would be in compliance with municipal requirements (e.g. zoning provisions, site plan, development agreement), or personal objectives. If the owner fails to rehabilitate the site, it is classified as “abandoned” and falls under the jurisdiction of the Management of Abandoned Properties Program (MAAP), which is discussed below.

If the owner chooses to be grandfathered under the ARA, they must apply for a licence. If the licence is issued, a site plan, meeting the same Provincial Standards is required, similar to a new application.

# 3.0 PLANNING ACT

The purposes of the Planning Act are set out in Section 1.1 as follows:

(a) to promote sustainable economic development in a healthy natural environment within the policy and by the means provided under this Act;

(b) to provide for a land use planning system led by provincial policy;

(c) to integrate matters of provincial interest in provincial and municipal planning decisions;

(d) to provide for planning processes that are fair by making them open, accessible, timely and efficient;

(e) to encourage co-operation and co-ordination among various interests; and

(f) to recognize the decision-making authority and accountability of municipal councils in planning.

The Planning Act requires that decisions of municipalities and local planning boards be consistent with matters of provincial interest including the conservation and management of natural resources and the mineral resource base, and provides for municipalities to pass zoning by-laws which in part will prohibit the use of land except as permitted in a zoning by-law. The establishment or operation of a pit or quarry is a “use of land” for the purposes of this section (Section 34 (1) 1. and (2)).

## 3.1 Provincial Policy Statement (PPS)

As noted in the Introduction, the PPS sets a policy framework for matters of provincial interest, including aggregate resources. Section 2.5.3.1 of the document specifically requires the progressive and final rehabilitation "to accommodate subsequent land uses, to promote land use compatibility, and to recognize the interim nature of extraction" and to "take surrounding land use and approved land use designations into consideration".

Where aggregate operations are located in areas of the province not designated under the ARA, the PPS encourages standards for rehabilitation that are compatible with those under the ARA. (Section 2.5.3.2)

# 4.0 GREENBELT ACT

The Greenbelt Act (Greenbelt 2005) and the Greenbelt Plan, February 28, 2005, includes lands within by the Oak Ridges Moraine Conservation Plan, the Niagara Escarpment Plan, and the Parkway Belt West Plan Area. The Act as implemented by the Plan requires progressive and final rehabilitation that contributes to the goals of the plan.

Specifics of the Greenbelt Act, Niagara Escarpment Plan and the Oak Ridges Moraine Conservation Plan are discussed in more detail relative to rehabilitation in Chapter 6.

# 5.0 NIAGARA ESCARPMENT PLAN

New Mineral Resource Extraction Areas are permitted by the Niagara Escarpment Plan only in areas designated Escarpment Rural Areas. Relative to rehabilitation of mineral resource extraction areas, the Niagara Escarpment Plan (2005, update 2009) outlines a number of objectives to ensure that rehabilitation provides for uses that are compatible and integrated with surrounding land uses and landscapes.

# 6.0 OAK RIDGES MORAINE CONSERVATION ACT

The Oak Ridges Moraine Conservation Act and the Oak Ridges Moraine Conservation Plan (ORMCP) apply to the specific area of this landform. Any amendment to an official plan or zoning by-law to establish or expand a licence application must conform to this Plan. Along with other policies regarding rehabilitation of aggregate operations, the ORMCP encourages municipalities and the mineral aggregate sector to work together to develop and implement comprehensive rehabilitation plans for those areas affected by mineral aggregate operations.

Municipal Official Plans and Zoning By-laws may not contain policy or provisions that are more restrictive relative to Mineral Aggregate Operations than ORMCP (Section 33. (2)).

## 7.0 PLACES TO GROW ACT

The Places to Grow Act and related Growth Plan for the Greater Golden Horseshoe (GPGGH) provide policies for how and where urban development should best and most appropriately occur and encourages the intensification of growth, both in population and jobs, within the existing communities to create compact, transit supportive, and complete communities. Relative to aggregate rehabilitation, the Plan encourages "coordinated approaches... where feasible" (GPGGH Section 4.2.3.).

## 8.0 LAKE SIMCOE PROTECTION ACT

The Lake Simcoe Protection Act, which applies to the Lake Simcoe watershed, is part of the provincial government's strategy to protect and restore the ecological health of the Lake.

With respect to rehabilitation of pits and quarries, the Act applies to lands outside the Greenbelt and Oak Ridges Moraine. Applications for a new pit or quarry within a key natural heritage features, key hydrologic feature or related protection zone must demonstrate that:

- the health, diversity and size of key natural heritage features be maintained or restored, and where possible improved for net gain; and
- any extraction in these features will be completed, and the area rehabilitated, as early as possible in the life of the pit or quarry.

All applications for new operations must demonstrate how connectivity will be maintained throughout the operations and how any habitat lost will be immediately replaced or restored on the site or adjacent lands.

# 9.0 GOVERNMENT ROLES IN LICENCED OPERATIONS

## 9.1 Ministry of Natural Resources

The Ministry of Natural Resources (MNR), through the aggregates program, is responsible for the management of aggregate resources in the province. The objectives of MNR's aggregates program are to minimize adverse impacts, contribute to ecological sustainability, protect aggregate resources and ensure they are available through participation in the municipal planning process, and promote conservation of the resource through reuse and recycling of aggregate (www.mnr.gov.on.ca/en/Business/Aggregates).

With respect to the rehabilitation of pits and quarries, it is MNR's responsibility to:

- Review, create and implement policies for the management of aggregate resources;
- Provide direction and interpretation of the policies;
- Process applications for licences and permits including requirements for rehabilitation; and
- Inspect aggregate operations and to ensure compliance with the Act, including those related to rehabilitation.

## 9.2 Ministry of Transportation

MNR has given the Ministry of Transportation (MTO) the authority under the ARA for the issuance and management of wayside permits and aggregate permits where the aggregate is required for provincial road projects. MTO's role includes processing applications, conducting inspections and enforcement (www.mnr.gov.on.ca/en/Business/Aggregates).

## 9.3 Ministry of Northern Development, Mines and Forestry

The Ministry of Northern Development, Mines and Forestry (MNDMF) responsibilities include the identification and mapping of significant mineral aggregate resources in selected regions of Ontario. MNDMF publishes reports on geographic areas entitled "Aggregate Resource Inventory Papers (ARIP)". These papers provide geological information and an assessment of aggregate resources to assist in preparing planning strategies and official plan policies including an assessment of sand, gravel and crushed stone resources (www.mnr.gov.on.ca /en/Business/Aggregates).

## 9.4 Environmental Commissioner of Ontario

The Environmental Commissioner of Ontario (ECO) monitors and reports on the government's compliance with the Environmental Bill of Rights (EBR), including the Statement of Environmental Values of the MNR, to ensure that the natural environment is protected and conserved for the future. The ECO acts as an independent environmental review body which provides annual and special reports to the Legislative Assembly; public education; and assists ministries when requested.

## 9.5 The Ontario Aggregate Resources Corporation (TOARC)

The Aggregate Resources Trust (The Trust) was incorporated in 1997 to administer portions of the Aggregate Resources Program that was formerly administered by MNR. The Ontario Aggregate Resources Corporation (TOARC) is the trustee for The Trust and is responsible for the collection and disbursement of the aggregate fees, the rehabilitation of abandoned pits and quarries, the rehabilitation of sites where licences or permits have been revoked, the collection and publication of production statistics and other information, and the education and training of those in or interested in the aggregate industry (www.toarc.com/home). TOARC is not responsible or involved with the rehabilitation of licenced pits and quarries.

The original purposes of the Trust include:

- Rehabilitation of land for which a Licence or Permit has been revoked and for which final rehabilitation has not been completed;
- Rehabilitation of abandoned pits and quarries, including surveys and studies respecting their location and condition;
- Research on aggregate resources management, including rehabilitation;
- Payments to the Province and upper and lower tier municipalities in accordance with regulations made pursuant to the Act; and
- Management of the Abandoned Pits and Quarries Rehabilitation Fund;

The TOARC mandate was expanded in 1999 to include education and training related to management of the aggregate resources and publishing of related information (www.toarc.com/corporate/formation).

Annual reports are prepared by TOARC detailing financial affairs, a statistical update, and a report on the MAAP program described below.

### 9.6 Management of Abandoned Aggregate Properties (MAAP)

The Management of Abandoned Aggregate Properties (MAAP) is administered by TOARC and funded by the Abandoned Pits and Quarries Fund. The aggregate industry contributes ½ cent for every tonne of aggregate removed from all licences and wayside permits each year to this fund through the annual licence fee.
(http://www.mnr.gov.on.ca/en/Business/Aggregates/2ColumnSubPage/263752)

The MAAP program uses this fund to rehabilitate abandoned pits and quarries defined by MNR as sites not under licence since 1990. Varied methods are utilized in the rehabilitation and sites are monitored for success or failure. Documentation is prepared to record the methods and results of the completed projects. In addition, the program's mandate is to encourage, support and manage research regarding rehabilitation and encourage partnership development in projects. (Manual Policy A.R. 5.00.19, March 15, 2009)

Since 1990, 420 ha of land has been rehabilitated to agricultural, wetlands, grasslands and recreational uses under MAAP at a cost of $4.5 million, with funding contributed by TOARC and other matching contributions (www.toarc.com/maap/information/overview).

## 10.0 INDUSTRY ASSOCIATIONS

### 10.1 Ontario Stone Sand and Gravel Association (OSSGA)

The OSSGA is an industry association representing producers of stone, sand and gravel in the province of Ontario along with suppliers of industry products and services. OSSGA promotes the responsible use of these resources by encouraging stewardship and the maintenance and enhancement of the environment. OSSGA works in partnership with government and the public to promote a safe and competitive aggregate industry contributing to the creation of strong communities in the province (OSSGA Mission, Annual Source Book 2009-2010).

One of the objectives of OSSGA is to increase public awareness and recognition of the need for a responsibly managed aggregate industry, which of course includes rehabilitation. To that end, OSSGA has a Community Relations and Rehabilitation Committee made up of a staff representative, and members (pit and quarry operators) and associate members (consultants and service providers). Among other tasks, this committee organizes an annual Rehabilitation Tour that is open to members, non-members and government employees. Each year a different theme or topic is discussed in a class room setting, with guest speakers, followed by a tour of various pits and quarries. This tour is held in different areas of the province each year.

The Community Relations and Rehabilitation committee is also responsible for reviewing and assessing the Industry Advancement Awards, issued annually by OSSGA. Guests are invited from outside the industry to assist in the judging process. The Industry Advancement Awards Program recognizes member companies that excel in community relations, progressive rehabilitation and property enhancement. Three special awards are also issued: The Award of Excellence, recognizing a culmination of multiple initiatives; The Bronze Plaque, recognizing outstanding final rehabilitation; and The Environmental Achievement Award, recognizing the development of and successful implementation of industry-leading policies, programs or projects that make positive contributions to the environment. (OSSGA website http://www.apao.com/)

## 10.2 Canadian Land Reclamation Association (CLRA)

CLRA is a non-profit organization incorporated in Canada in 1975 with members throughout North America and other countries. The main objectives of CLRA are to provide opportunities for its members to share information about problems and solutions, research and practical experience, to encourage education and corporate involvement,and to acknowledge significant achievements in land reclamation.

# CHAPTER 3

# SAROS PAPER 6: REHABILITATION

# PUBLIC EXPECTATIONS OF REHABILITATION

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# 1.0 INTRODUCTION

Rehabilitation has been a requirement under the Aggregate Resources Act, and previously, under the Pits and Quarries Control Act since 1972. Some 40 years later, there is growing criticism of the aggregate industry that rehabilitation is not being sufficiently undertaken, and of the Ministry of Natural Resources (MNR) that rehabilitation requirements and plans are not being adequately enforced. Most would agree that there are some excellent examples of quality rehabilitation to agriculture and to natural heritage features. Most would also agree that rehabilitation within urban environments provides opportunities for residential, commercial and industrial development, along with a variety of recreation opportunities. However, the current concerns suggest that notable examples are the exception and that rehabilitation today takes too long to achieve.

Chapter 3 of the Rehabilitation Paper explores public expectations for rehabilitation. Specifically, this chapter is to *"Comment on public expectations related to amount, timing and quality of rehabilitation."* This paper discusses the view and expectations of a variety of stakeholders, including members of the public and various groups/organizations, with some knowledge of aggregate extraction and rehabilitation. Contacts were chosen to represent a broad spectrum of the public, and these contacts were asked a set series of questions regarding rehabilitation (listed in section 2.2). Their responses are summarized below, and based on their responses and broader research, conclusions and recommendations are identified.

## 1.1 What is Rehabilitation?

Generally speaking, rehabilitation of pits and quarries refers to the grading, replacement of soil, and re-vegetation to transform depleted pits and quarries to a post-extractive land use or uses. The concept of rehabilitation can be further separated into progressive and final rehabilitation. Progressive rehabilitation refers to rehabilitation that is initiated in depleted areas of the pit or quarry, while extraction continues in other areas. Final rehabilitation is the process of completing the last stages of progressive rehabilitation (such as the removal of a processing plant) and development of the final end use. Once final rehabilitation is completed to the satisfaction of the MNR, the licence is surrendered and there are no further obligations or responsibilities on behalf of the operator under the Aggregate Resources Act. Chapter 2 –Legislative Framework expands on definitions of rehabilitation and which legislation specifies rehabilitation requirements.

## 2.0 APPROACH TO CHAPTER 3

A great deal of attention has been paid to the amount and quality of rehabilitation, most recently reported and discussed by the Environmental Commissioner of Ontario (ECO). In Annual Reports of that office, and in the discussions hosted with various stakeholders (e.g. Aggregate Round Table, 2006), the lack of progressive rehabilitation on an annual basis was identified as an issue. The ECO, Gord Miller commented that rarely was rehabilitation implemented to return lands to original landscapes: rather, they were rehabilitated to alternative land uses such as golf courses and subdivisions.

Issues around the apparent lack of rehabilitation, the apparent lack of diversity of functions captured by rehabilitation, and the absence of ongoing monitoring of upgraded rehabilitation have been raised by the public and by many stakeholder groups (e.g. Gravel Watch, Coalition on the Niagara Escarpment, Conservation Ontario, Ontario Nature, Pembina Institute, etc.), especially in the recent past.

The intent of this chapter is not to quantify how much land (in terms of hectares) is being rehabilitated, but rather to gain a current measure of public sentiment about rehabilitation by contacting key individuals and groups involved in and/or related to the industry and discussing their views on expectations of rehabilitation.

### 2.1 Contacts

In reaching out to obtain the public expectation on rehabilitation, a balanced representation of agencies and organizations having involvement and/or knowledge of rehabilitation of pits and quarries were contacted. Aggregate producers were deliberately not contacted for their input on this Task. While they have substantial collective experience working with agencies, groups and the public, the aim of this specific exercise was to reach out to groups independently and generically, and to divert away from discussions related to specific companies or properties. The following is a list of the agencies/organizations that participated in this aspect of the study:

- Canadian Land Reclamation Association (CLRA)
- Community Relations and Rehabilitation Committee (OSSGA)
- Couchiching Conservancy
- Environmental Commissioners Office (ECO)

- Gravel Watch
- Niagara Escarpment Commission (NEC)
- Ontario Stone, Sand and Gravel Association (OSSGA)
- Toronto Region Conservation Authority (TRCA)

## 2.2 Discussion Questions on Public Expectations for Rehabilitation

The questions that were asked of the contacts are as follows:

1. a) What are your expectations for progressive and final rehabilitation?
   b) In terms of amount, do you think there is enough land being rehabilitated?
   c) Could it be increased? If so, how?
   d) In terms of timing, is rehabilitation occurring as quickly as it should?
   e) If not, why not?
   f) Is rehabilitation occurring satisfactorily in terms of quality?
   g) If not, what would improve it?
   h) Are rehabilitation objectives (i.e. recreation, agriculture, natural heritage, development) adequately responding to socio-economic and ecological priorities?

2. a) Based on your experience with broad public comment on rehabilitation, how would you describe the public's expectations regarding rehabilitation of pits and quarries and whether they are being met?

3. a) Are you or your staff engaged in any periodic observations regarding rehabilitation examples and advancements?
   b) What site or sites stick in your mind as either very positive or very negative examples of rehabilitation?
   c) Do you see a role for public education in rehabilitation? (e.g. tours, open houses, etc.)
   d) Do you see a role for engaging/partnering with the public in rehabilitation? What sort of engagement? (e.g. tree planting, tours, monitoring, and meetings)
   e) Who do you think would be natural partners/collaborators in rehabilitation efforts?
   f) How are rehabilitated sites identified (e.g. plaques, signage)? Should they be?

These questions, in most cases, were a starting point for discussions that extended well beyond the specifics noted. The results are a comprehensive perspective of expectations for rehabilitation and new ideas that were suggested to improve aspects of rehabilitation.

### 2.3 Other resources

As part of our feedback from the Technical Expert Panel and the Aggregate Resource Advisory Committee guiding the SAROS Study, we received a request to review the following documents, as part of our research.

1. Rebalancing the Load: The Need for an Aggregates Conservation Strategy for Ontario, The Pembina Institute, Mark S. Winfield, Amy Taylor, January 25, 2005.

2. Rehabilitation of Ontario’s Aggregate Pits and Quarries: Who Will Pay for It?, Application for Review under Section 61, Ontario Environmental Bill of Rights, of the Aggregate Resources Act With Respect to Rehabilitation of Ontario’s Pits and Quarries, Richard C. Holt and Edward S. James, October 14, 2003.

3. Ministry of Natural Resources, Environmental Bill of Rights – File No. R2003008, Review of the Aggregate Resources Act with respect to “Rehabilitation of land from which aggregate has been excavated”, July 2008.

These documents were reviewed and highlights are reflected in this chapter. Additional references are included at the end of this chapter.

## 3.0 RESULTS

### 3.1 General

Comments received from the contacts were extremely thoughtful and insightful. All of the people we contacted were interested in the study, and wanted to participate. In some cases, efforts were made to make sure we spoke with the most knowledgeable person representing the group, and in one case a conference call was held so multiple representatives could participate. The level of engagement in this task was significant, a reflection of both the perceived importance of this discussion and of the sense of appreciation by many for the opportunity to provide input.

Given the wide range of people/groups contacted, it was expected that comments would vary widely. This was not entirely true. It is interesting to note that there were some consistencies in responses, and groups that are often in opposition to one another were offering similar suggestions and raising similar concerns. This study provided the opportunity to listen to a variety of voices in a neutral dynamic, without the rather charged environment normally associated with this dialogue. The identification of many commonalities points to significant opportunities to create positive gains associated with rehabilitation. Comments are included in this report in the boxes below.

Discussions were initiated by asking what individual expectations were for progressive and final rehabilitation. The following summarizes responses, in no specific order:

**Expectations for Progressive and Final Rehabilitation**

- Rehabilitation must ensure a compatible after use with surrounding lands;
- Progressive rehabilitation should return the land back to what it was before extraction (e.g. agriculture or natural heritage features);
- There needs to be a variety of end-uses such as agriculture, recreation and development. There seems to be a push now for biodiversity, and the value of other end uses must continue to be recognized;
- It is a reasonable expectation to make the land after extraction as good as it was before;
- Progressive rehabilitation should be visible in a lifetime;
- Rehabilitation should be done as quickly as possible after extraction, using the best tools available;
- For pits above water, rehabilitation should provide a useful state, such as agriculture, or function as part of a natural ecosystem;
- For below water extraction it is a different situation as it is not possible to restore the land to its original condition. As a result there should be consideration of offsets (e.g. destroy habitat in one area obliges an operator to restore similar habitat in the vicinity);
- Progressive rehabilitation results should be seen on an on-going basis. This should be visible from the air, to see neat, organized progress over the years;
- If extraction is truly an interim land use, then there needs to be an interest in the long term use,

**Expectations for Progressive and Final Rehabilitation**

by the public and by the operator;

- The requirement for progressive rehabilitation should not enable operators to leave an open pit or quarry as a sterile resource over the years;
- Progressive rehabilitation should show a level of care and concern from berm development and maintenance to slopes and shorelines. This illustrates an investment and interest on the part of the operator;
- The expectation is to see progressive rehabilitation, and in most cases, the public does not see into licensed pits or quarries. This leads to the perception that there is no rehabilitation underway; and
- Wherever possible, progressively rehabilitated land should go into public ownership. Extraction covers such a long period of time, there should be some end benefit for the public. Public partnerships and end use should be considered during progressive rehabilitation as well to get the community to engage with the transition of the pit/quarry and maximize rehabilitation opportunities.

Contacts were also asked what they thought the public's perspective was on rehabilitation. Comments indicated that observed public expectations are varied, and are summarized below:

**Public Expectations on Rehabilitation**

- Public relations and education about rehabilitation is lacking, and what exists is not reaching the public;
- The public's expectations are not being met, particularly relative to rehabilitation to natural heritage features. The public sees licences as a total loss of natural heritage features for all time, and this causes hostility. There are some people who are interested in working with companies that are trying to do the right thing (e.g. net gain and compensation). Producers that tend to be more successful are working towards public interests, with less focus on corporate financial gain;
- The public does not have any expectation about rehabilitation because they are not aware of it, or don't understand it. This is because the rehabilitation is so good the public is not aware it

**<u>Public Expectations on Rehabilitation</u>**

was a pit (e.g. agricultural lands, urban development). The industry is not getting the rehabilitation message out about these successful outcomes;

- Most people have a very narrow understanding of what is available for rehabilitation, therefore their expectations are narrow. This leads to continual disappointment of what the industry does;
- There is general dissatisfaction by the public because they believe rehabilitation is not happening. The public sees "show-case" sites, yet recognizes this is not representative. This causes the public expectations to be unrealistically high, and not likely to be met on most sites;
- There is confusion between in-active sites and depleted sites. It is often assumed that if a site is inactive, the operator has left and will not be carrying out rehabilitation;
- The industry should be focusing on after-use, as opposed to rehabilitation. There is not enough attention paid to real value in the land and how it can best be used, instead of meeting the minimum requirements for sloping and seeding. This is difficult due to the long term investment in pits and quarries; and
- There is a general scepticism by the public that the rehabilitation proposed is not possible, that MNR is unable to enforce the rehabilitation as noted on the site plan, and many companies do not have the will to do the rehabilitation as promised.

## 3.2 Amount of Rehabilitation

Most contacts agreed that there is not enough rehabilitation occurring on an annual basis although a number of people mentioned they had no way of knowing. It is difficult to quantify, as statistics are not readily available from MNR, and the accuracy of numbers available is uncertain.

It was also suggested that the larger producers tend to be able to do a better job in terms of the amount of rehabilitation, than smaller producers. Another disparity noted was in geographic areas – some areas of the province there is enough rehabilitation being completed, whereas in other areas there needs to be a more concerted effort.

It was suggested that the industry should be doing more rehabilitation on an annual basis. Things have improved over the years, but there still is a long way to go. It was further suggested that it would be helpful if the industry reported annually on the amount of rehabilitation that is being undertaken, and if that number was high, it would certainly help with the perception of the amount of progressive rehabilitation that is on-going.

A number of reasons for the lack of rehabilitation were identified and include:

**Reasons for Lack of Rehabilitation**

- Requirements on site plans for rehabilitation for the old licences are not as high as the sites being licensed today. As a result, some sites only require rehabilitation to a "dry bowl". The Provincial Standards are not necessarily higher now, but some applications develop more details on progressive rehabilitation prior to licensing due to an interest in providing a more useful and ecologically valuable end use, and due to increased public and agency comment and involvement.
- There are not strong enough requirements on individual site plans to ensure progressive rehabilitation.
- MNR does not have the personnel or political will to enforce rehabilitation as defined in the ARA. Staff cuts in the program illustrate this. MNR Inspectors cannot keep up with their workload. There is scepticism that they get to every site, and it raises the question as to, "who is minding the store". There must be adequate enforcement to deal with operators that are not following the rules.
- Not only is there an inability to enforce, where required, but if MNR is not reaching the operators, or visiting the licences, there is no opportunity to educate the operators. This is particularly a critical loss for those operators that work in relative isolation, without the benefit of expert input (e.g. do not retain consultants, do not have property managers on staff, or are not members of the industry association – OSSGA). Without these resources, the MNR is the only link for information and advice on rehabilitation.
- Site plans should be both designed with stricter obligations for progressive rehabilitation and more strictly enforced to require progressive rehabilitation as identified within the ARA.
- A licence needs a mechanism to make the rehabilitation happen. An example would be a 20

**Reasons for Lack of Rehabilitation**

year review, or a sunset clause with a time period for the licence. MNR needs to be identifying steps to require rehabilitation.

- There needs to be more openness surrounding rehabilitation. The public should know where rehabilitation is occurring, and should be able to access information about the rehabilitation. This information, along with information such as how long areas have been disturbed is very hard to access.
- There needs to be more ability to import and blend aggregate products so that the poorer quality material left over on some licences can be blended and extracted as a new product, and sites finally rehabilitated.
- There needs to be more rigour of management (e.g. a materials management plan) to keep the footprint of disturbed area constrained. Other industries are controlled in this fashion.
- There should be a cost to keeping land disturbed, a negative incentive.
- Operators need to realize rehabilitation is more than compliance. There is a link missing between the design and actual site work in many cases. Additionally, most companies do not have a rehabilitation specialist, so a current, innovative and knowledgeable resource for rehabilitation is not necessarily present.
- Companies often do not look at the property from a long term perspective, and miss out on value added opportunities that progressive and final rehabilitation can offer.
- Rehabilitation is not the main business of operators, and takes the backseat to production.

## 3.3 Timing

Most of the contacts stated that rehabilitation was not occurring as quickly as it could. They noted that progressive rehabilitation should be initiated as soon as possible, not in "the fullness of time." It is recognized that there are legitimate operational reasons that prevent progressive rehabilitation from occurring in certain areas.

It was believed by respondents that since most licences don't have time limits, this, among other things, has lead to many operators simply not complying with their rehabilitation obligations.

Examples cited by respondents of why rehabilitation is not accomplished as quickly as it could be include:

**Timing of Rehabilitation**

- Secondary uses take over (such as processing) and the area cannot be rehabilitated until the entire site is depleted;
- Producers argue that they need all the area open for operations;
- Agencies (e.g. conservation authorities, Niagara Escarpment Commission, municipalities, and MNR) sometimes have competing interests regarding rehabilitation, and their standards are not the same;
- Companies do not financially plan for rehabilitation, and there is a lack of money available for rehabilitation;
- Many companies have a lack of knowledge of how to start and integrate rehabilitation into yearly operations;
- There is a lack of incentive to rehabilitate. There needs to be a higher profile corporately for rehabilitation so it is in the minds of companies daily – respondents note that it comes after operations in terms of dollars and attention;
- The respondents recognized that the licensing process is increasingly complex, long and costly. Since producers have to ensure future reserves for the continuation of their company, some producers licence properties before they are required, for future security. As a result, some sites may sit idle before they are extracted. If the process were streamlined, there may not be as much land licensed;
- There needs to be incentives to rehabilitate sooner – in many cases compliance with the site plans is not an adequate tool;
- There is a lack of compliance with the site plans on behalf of the operators; and
- There is a lack of enforcement on behalf of MNR to ensure operators are in compliance with their site plans, largely due to underfunding of the aggregates program and the resulting lack of field staff. Inspectors have too large an area to cover and additional field staff is required.

## 3.4 Quality

There were mixed comments from respondents regarding the quality of rehabilitation. Most people would agree that there are some excellent examples of rehabilitation. Most would also agree that there are sites that have quite limited rehabilitation. Most respondents note that with a base level of effort, sites could be significantly improved in terms of final landscape, value and/or function.

It was noted that there is no evaluation of or information available on, how well the rehabilitation is being implemented, unless the operator undertakes a monitoring role on their own accord. There is no certification of the progressive rehabilitation, and no apparent feedback as to how it could be improved as MNR does not get to every site, every year.

Some respondents raised concerns that in many cases, it is not possible to return the land to the same or similar land use. Therefore it is not in fact rehabilitation but rather redevelopment to a new use. In the case of extraction below water, the land base is removed to be replaced by water-based uses. Rehabilitation to a water body might be a desirable use, depending on the quality of rehabilitation and interests of the local community. However, the removal of the original land-based use, even though it may be rehabilitated to something else, is a point that many respondents remain concerned with.

Some respondents noted that some rehabilitated pits or quarries have life-time monitoring or maintenance responsibilities, which can be onerous especially if the land is returned to public use. In some cases there are not budgets in place for maintenance; in other cases there are examples where producers have worked with agencies to put funding in place for future monitoring and/or maintenance.

It was clear in discussing rehabilitation quality that many were aware of the "showcase" rehabilitation examples in the province. Most could reference rehabilitation examples that were not successful. There was not a strong awareness of the majority of rehabilitated sites that are integrated into the surrounding landscape to the extent that they are no longer recognized as former pits or quarries.

Many respondents note that there appears to be a difference in quality of rehabilitation relative to the final end use. Rehabilitation to agriculture was felt to be generally successful. Respondents felt that there are examples of adequate, and in some cases very good, rehabilitation. Similarly, rehabilitation to recreation and development was seen as successful, with some excellent examples. However, rehabilitation to natural heritage and aquatic features was noted to be a long way from achieving wide spread success.

Examples cited by respondents regarding why the quality of rehabilitation is not as high as it could be:

**Reasons that Quality of Rehabilitation is not as High as it Could Be**

- Pit or quarry operators are focused on producing sand, gravel and stone. Their primary job is not rehabilitation and there are only a few companies that have experts retained to oversee their rehabilitation projects.
- It costs more to do more in terms of quality rehabilitation and there is no incentive to do this if it is not required on the site plans.
- The application of rehabilitation as per site plan requirements (ones that have details) has not been rigorous enough.
- The site plan process continues to improve, providing more details to establish functioning ecosystems, but most site plans dating back to the early 1990's are lacking detail.
- Site plans need to deal with a final designation to public ownership. Given that a producer is asking for the public concession to extract aggregate where it exists, then there should be consideration of returning those lands to the public in some fashion.
- MNR Provincial Standards for rehabilitation are too low. Some sites exceed the minimum standards, but in order to positively affect the majority of sites the minimum expectations identified by the Provincial Standards need to be raised. Specifics can be established on a site by site basis, so that each pit or quarry develops a rehabilitation plan unique to that property. These do not have to be legislative changes, and they do not have to cost the operator more. It takes more planning and commitment.

## 4.0 International Examples of Rehabilitation Meeting Public Expectations

In researching rehabilitation in other areas of the world, it became apparent that there are many good examples of industry working with local communities and organizations to reach mutually acceptable goals, as well as different examples of legislative controls.

### 4.1 Legislative Controls

In the United Kingdom, progressive rehabilitation is required under the British Aggregates Act and includes very tight timelines for progressive rehabilitation. In Greece, licences are issued for a fixed time period of 30 years, after which the licence is revoked. Innovative Partnerships

The following are select examples of innovative partnerships between the aggregate industry and a range of organizations. Others are provided in Chapter 10.

Hanson Cement launched a UK biodiversity and geodiversity action plan in 2005, and as part of this initiative they signed a memorandum of understanding with English Nature (now Natural England). The agreement was aimed at improving standards of conservation management in both active and disused quarries, including working closely with Natural England in the planning of rehabilitation strategies (HHCG 2009).

In Bernieres-sur-Seine, northwest of Paris France, Lafarge France was interested in expanding extraction area to include an old oxbow of the Seine river. However, the local municipality did not want to see trucks travel through their village to transport the materials so through a series of negotiations, a large 600 m conveyor belt was constructed across the Seine. While the restoration plan includes the rehabilitation of an old pine plantation with native species to create a more biodiverse system, the local residents stated that they did not want to see restoration efforts of this nature near the village. Instead, they were interested in having fruit trees planted and this was accommodated by Lafarge (Moreen Miller, pers. comm., July 27, 2009).

Lafarge Meadows is the rehabilitation of a sand and gravel pit in south Calgary, Alberta, which has resulted in a 147 ha extension to the Fish Creek Provincial Park. The site includes a large constructed wetland, First Nations historical sites, vital wildlife corridors and protected riparian areas, all within the boundaries of a major urban centre (Emerald Foundation). Partnerships, particularly community partnerships, were critical to the success and continuation of the project.

The Provincial Park was a major partner throughout the project, and a unique partnership was established with a local Funeral Home. A memorial forest has been established, with an annual tree planting ceremony in memory of people that have passed away. Planting can continue for the next twenty years, while also further developing community involvement and ownership in the rehabilitated lands. Lafarge received the 2009 Emerald Award, supporting environmental excellence (Alberta Emerald Foundation 2009).

CEMEX has signed a 10-year agreement with BirdLife International, a global partnership of national non-governmental conservation organizations in over 100 countries and territories aimed at conserving wild birds and their habitats. The agreement is focused on ensuring the integration of the technical advice of BirdLife International into the management and restoration of the over 400 quarry sites operated by CEMEX around the world to benefit and minimize impacts for bird populations at CEMEX sites. Since 2000, CEMEX has purchased over 120,000 hectares of land and has entered into conservation agreements with adjoining private landowners to secure an additional 60,000 hectares. CEMEX has also established a hands-on research center at their El Carmen site, giving priority to scientific work, habitat restoration, and wildlife management programs. A technical advisory board made up of scientists, local landowners, and other representatives to help identify and implement research and restoration activities oversees all of this work (CEMEX 2009c).

Heidelberg Cement is developing a nature trail in cooperation with Neckar-Odenwald Geo-Rangers, with part of the trail located in inactive parts of the site open to the public, and the other part of the trail for guided tours. The latter allows visitors to gain panoramic views of the active quarry from a platform. Since 2006, more than 2,000 visitors have participated in guided tours through the quarry (WBCSD 2009).

Information on these partnerships was readily available through internet research and corporate publications. It is recognized that smaller operations are also often involved in partnerships, particularly at the local level. Unfortunately, further exploration of specific examples was not possible within the time frame of this study.

## 5.0 CONCLUSIONS

Based on interviews with contacts, it is apparent that although there are exceptions, overall the industry is not meeting public expectations: not enough rehabilitation is occurring, nor is it occurring fast enough. Compare this with the statistic from Task 1, which illustrates that 40% of the random 50 licenced pits and quarries inventoried do not have any progressive rehabilitation underway, and it would appear that the opinion of the contacts interviewed are borne out by the results of this small, random field survey. In fact, MNR agrees with this in the conclusions of their 2006 review of the ARA, when they state "*Although there are many examples of companies performing excellent progressive rehabilitation, it is apparent that a significant component of the aggregate industry is not making sufficient efforts to progressively rehabilitate their aggregate sites as evidenced by an inventory of licences conducted on the Oak Ridges Moraine and from discussions held with aggregate inspectors.*" Encouragingly, there was consensus amongst respondents and evidence from other examples that there are mechanisms that could be put in place to increase the amount and timing of rehabilitation. There was a belief by respondents, that with new incentives in place, both the timing and amount of rehabilitation can be increased.

Some criticism of the amount and timing of rehabilitation by contacts interviewed has also suggested that there should be a direct link between disturbed area and rehabilitated area in any given year. There is no evidence or mandate to suggest that the two are linked. This was reviewed in the CUI report and it was determined that the ratio of disturbed land to rehabilitated land has never achieved a 1:1 balance (although it came quite close in 2003). The report goes on to state the reason for this could be due to the cost of rehabilitation or that rehabilitation techniques must be carefully tailored to each site and its surrounding land use (Canadian Urban Institute, 2009). It is our conclusion that each site should be maximizing the area to be rehabilitated as soon as practical. The very nature of pit and quarry extraction provides for unique sites that vary over their lifespan. For instance, a deeper pit or quarry will take longer to be extracted to the limit of extraction before progressive rehabilitation will occur than a shallow deposit. Pits or quarries starting up in the early years of extraction have less opportunity for progressive rehabilitation than those further along in the extraction process. Quarries that extract below the water table offer opportunities for shoreline rehabilitation, but until the site is depleted, and the pumping ceases, there are limited opportunities for durable rehabilitation. And finally, in order to maximize efficiencies and soil quality, rehabilitation does not often occur unless there is stripping required as well.

However, this is not to say that there cannot be some rehabilitation done.  Even small amounts benefit the site, and are a positive reflection of the company. As evidenced from this study and, in particular the review of Tasks 1 and 2 sites, efforts by landowners to carry out some level of progressive rehabilitation on a visible, ongoing basis is necessary, and supported, but unfortunately lacking on many properties.

Views on the quality of rehabilitation amongst contacts interviewed were varied, and ranged from being satisfied with the quality of rehabilitation, to identifying that there should be greater attention to the landscape context, as opposed to individual licences.  For instance, in sites to be rehabilitated to natural ecosystems, it is necessary to understand linkages and the role the site can play in the broader landscape.  In developing a new landscape, the opportunity exists to create what is most appropriate to optimize landscape ecology.

Respondents expressed a lack in confidence that MNR has the resources to carry out its role as a regulator.  Most noted that there is a lack of support and funding for the program that enables the Aggregate Resources Officers to get into the field and work with the operators towards improved rehabilitation. As one contact stated "*Everything falls down if MNR is not properly equipped*".

The need to increase education and work in partnership go hand in hand.  There is an atmosphere of scepticism or distrust by the public of the aggregate industry.  The existing negative image of the industry among the public cannot be reduced through education alone (CLRA, 2009).  What is required is the establishment of more open and collaborative communications amongst various stakeholders.  Rather than directing energies towards fighting against stakeholders and their positions, more beneficial outcomes will come from increased dialogue and partnerships.  A successful partnership is a relationship between organizations built on mutual trust (Whitbread-Abrutat, P. H. 2006).  The most successful partnerships are those that include representatives from the industry, the government and the public, as they all gain, and all can share a common goal.

There is much attention and research regarding the loss of one ecosystem to provide the opportunity for extraction of aggregates, but nothing required to recognize the return to the original land use or re-birth of a new land use.  Good rehabilitation makes the history of the site disappear and it is not being adequately recognized or recorded.

# 6.0 RECOMMENDATIONS

The discussions and interviews with selected contacts generated very diverse and helpful suggestions regarding how rehabilitation can meet public expectations. Furthermore, international examples prove that communication and partnerships can lead to increased opportunities for final land use through rehabilitation of pits and quarries. The following summarizes the recommendations brought forward through this study.

## 6.1 Suggestions to Increase Amount, Timing and Quality of Rehabilitation

i) Recognition Program

There is a certain prestige with being recognized for the achievement of excellence in the field of rehabilitation. The industry association, OSSGA, has a series of achievement awards for operations and rehabilitation that are presented to selected producer members of OSSGA on an annual basis. This program has served an important function in establishing benchmarks for excellence especially within the OSSGA membership base. Building upon this program, it would be appropriate to consider the establishment of a province-wide recognition program that captures all industry members including those within and outside of OSSGA. Ideally this program would be implemented and maintained by the province, in association with a number of collaborating or partnering groups. A recognition program would be a positive element to complement an effective enforcement monitoring program for progressive rehabilitation.

ii) Information on Rehabilitation Must Reach Operators

MNR should provide more information to operators on when and how they can undertake progressive rehabilitation. This would be effectively facilitated through an annual site visit, where the Inspector reviews the operation and ensures the operator has been appropriately implementing progressive rehabilitation.

iii) Companies, Public and Agencies Benefit from Open-Door Policy

Some leading companies have opened their doors to the public and agencies in the form of Community Open Houses. These are beneficial in terms of maintaining and enhancing community relationships. Some companies have extended this approach and are inviting agencies to review annual monitoring reports and discuss aspects of the operation that are of interest.

iv) Incentives

Without exception, all respondents agreed that it is necessary to establish an incentive program for the operator, in order to obtain faster and better rehabilitation. It was recognized that incentives can play a role to increase rehabilitation in addition to the enforcement requirement and the desire to do the right thing. Examples for incentives put forward include:

**Examples of Incentives**

- Some form of rebate program (respondents cited apparent success of the recent "Home Improvement Rebate");
- More innovative tax incentives as land is rehabilitated; (e.g. Currently rehabilitated land is assessed at a lower rate than disturbed land. If it were assessed lower than the pre-extraction land there would be a further financial incentive to rehabilitate as quickly as possible and keep disturbed area to a minimum.)
- Development of Certification Standards (e.g. Forestry Industry);
- Implementation of Best Management Practices; and
- An operator should have to earn the right to continue extraction (i.e. a social licence to operate).

v) MNR Needs to Encourage More Rehabilitation

MNR needs to increase efforts to educate those operators that need assistance with rehabilitation. There is information available (see Tasks 6 & 7 reports and associated references), but it is not necessarily reaching the producers in a useful manner. MNR should consider bulletins or annual reports that would assist operators. Furthermore, respondents noted that MNR needs to enforce the existing legislation. Some respondents noted that there needs to be a will to conform on behalf of both MNR and the industry.

Although a valuable position exists within the Science and Research Branch of MNR for rehabilitation, there is no parallel position in the Aggregate & Petroleum Resources Section. Up until the 1990's there was a "Rehabilitation Specialist" in this section that was a "go to" person for the Aggregate Resources Officers and was responsible for policy development on rehabilitation. If such a position were re-instated (either with current Policy Advisors, or a new position), there would be an information source for field staff, as well as an avenue to produce annual reports, analyze rehabilitation costs, publish newsletters, recognize good rehabilitation practices and provide educational updates, review licence applications to ensure practical and feasible rehabilitation, and field assistance. This would not only provide new information to operators and field staff, but it would assist in disseminating MNR's on-going research through TOARC and the Science and Research Branch

vi) Important MNR Research Requires More Dissemination

There is research being undertaken by both TOARC and MNR in the Wildlife Research and Development Section; however this information is not necessarily reaching the Aggregate Resources Officers, and ultimately the operators, in a practical manner. There needs to be more communication between TOARC and key MNR groups with a focus on getting practical and helpful information to the pit and quarry operators.

vii) Involve More People – Openness and Accountability

Currently, rehabilitation is the responsibility of the MNR and operators. Some respondents perceive this to be too tight a relationship, and point towards the potential benefit of including other agencies. Interestingly, it was also suggested that operators and MNR inspectors are not communicating effectively enough. With an increase in openness and accountability there is an opportunity to educate more people on the status of progressive rehabilitation.

viii) More Time and Resources to Research

More time and resources (both government and industry) need to be invested to better understand what rehabilitation techniques work and how they are suited to certain areas. This includes allowing operators more flexibility in terms of research and innovation on their properties. This has been resisted in some MNR districts.

ix) Involve University Students and Broader Academia

Some respondents noted that it is important to get students involved as they bring new ideas to the industry and they represent the future of pit and quarry rehabilitation. Involvement with academia is an opportunity to have research carried out and results published for broader integration with government programs.

x) <u>Partnerships</u>

In some cases, partnerships with local groups could enhance rehabilitation. There are a wide range of groups with specific expertise such as Tallgrass Ontario, Nature Conservancy of Canada, Ontario Invasive Plants Council, Ontario Federation of Agriculture, recovery teams for species at risk, etc. that would be well positioned to work with aggregate producers to assist in rehabilitation if the end result helped to further their individual mandates.

Some respondents are interested in providing increased access for local and interest groups (e.g. ORM, land trusts, etc.) for assuming rehabilitation requirements under agreements.

xi) <u>Eliminate Punitive Measures Which can Discourage Successful Rehabilitation</u>

Some producers have experienced designations being added to their properties, based on rehabilitation they have undertaken (e.g. tree planting resulting in significant woodland designations). Similarly, there is concern on behalf of some producers that they may be creating habitat that attracts Species at Risk. These positive outcomes should not be detrimental to the continued operation of the site, and should be carefully considered in terms of consequences for the end use after the licence is surrendered.

xii) <u>Comprehensive Rehabilitation Plans</u>

In order to increase the quality of final rehabilitation in areas where there are multiple licences on a deposit, comprehensive rehabilitation plans are necessary.

xiii) <u>Time Periods for Extraction</u>

Some respondents felt that a pit that has been left open for an extended period of time (e.g. 20 years) with no extraction, should be rehabilitated and the licence should be surrendered. This was raised as a particular sensitivity in some areas, where sites have been seen as eye sores for many years. Respondents stated that there should be a time limit for extraction, after which the public and producer know the site must be rehabilitated.

xiv) <u>Site Specific Increased Tonnages to Assist in Efficiently Consuming Resources</u>

Some sites are not rehabilitated because they have small amounts of material left. One suggestion is that the MNR could offer an increase in tonnage (where tonnages are low) so that the material could be removed all at once, allowing final rehabilitation to occur sooner.

xv) <u>Maximum Area Disturbed on the Site Plan</u>

There could be limits put on the site plan as to a maximum disturbed area. This should be limited to one area, so there are not multiple areas open at one time. Some respondents noted that this has occurred in the Greenbelt, through the Greenbelt Plan, but could be introduced province-wide through changes to Provincial Standards.

xvi) <u>Strengthening the Rehabilitation Requirements of the ARA</u>

One of the recommendations of the Report by The Pembina Institute (Rebalancing the Load, January 2005) states that “The requirements under the Aggregate Resource Act for the rehabilitation of pits and quarries should be strengthened. The expansion of existing operations should only be permitted on the basis of substantial progress on the rehabilitation of the disturbed area within the existing licensed area (generally no less than 50 % of rehabilitation of the disturbed area). In the meantime, the enforcement of the existing rehabilitation provisions of the Act should be significantly strengthened.”

This has been supported by a public request that the ARA be enforced and modified to provide rehabilitation in an open and accountable manner. Specifically, it was suggested amendments are required so that the ARA becomes effective in ensuring that rehabilitation actually takes place. It was felt this would require additional revisions to regulations and policies to support the clear intention of accomplishing progressive and final rehabilitation of the ARA (Holt, R, and James, E. 2003).

It was interesting to note that for many of the suggestions noted above, the policy and legislative framework currently exists to support these initiatives, and in some cases can be implemented outside the legislative framework.

MNR’s review of the ARA with respect to “rehabilitation of land from which aggregate has been excavated” (July 2006), determined similar results and concluded:

- The fundamental principles of the ARA and the specific sections of the Act, provide a solid foundation for achieving the purpose of carrying our progressive and final rehabilitation of aggregate sites.

- The ARA has the enforcement tools necessary for aggregate inspectors to ensure that progressive rehabilitation is carried out in accordance with the ARA.

## 6.2 Public Education on Rehabilitation

Most contacts felt there was a need to educate the public on rehabilitation efforts for pits and quarries. However, there was a caution that some forms of education could be detrimental. The public could see efforts as “green washing” if the industry promotes themselves as excelling at rehabilitation. The following is a summary of suggestions and ideas as to how to increase public education.

Suggestions for Increased Public Education

- Open Houses have been used by companies to open their doors and meet with neighbours. More attention to progressive rehabilitation would be beneficial and these Open Houses could be used to discuss what has worked and what has been learned in terms of preferred rehabilitation techniques.
- Use of Citizens Advisory Committees can be effective tools for education, sharing of information and listening to concerns.
- The Industry, Conservation Authorities, Municipalities, School Boards and TOARC can each contribute to communicating about successful rehabilitation projects. There are some fine examples of progressive rehabilitation that should be shared. Conservation Authorities and others could assist with programming and signage and offer an opportunity to partner in educational opportunities. Pits offer an opportunity to serve as outdoor classrooms.
- Tours can be an excellent way to educate the public on pit and quarry operations and rehabilitation. They can provide more information than an Open House, but some respondents suggested that tours are not always balanced.
- Signage may help educate the community. For instance, if a pit is used sporadically for local road jobs, a sign could be posted to describe the use of the material and the frequency. The

Suggestions for Increased Public Education

public would better understand the reason for pits being left "fallow".

- There needs to be more education on operations and rehabilitation as the two are (or should be) connected. Education should contribute more to an understanding of rehabilitation. It is also important to understand what was learned from rehabilitation efforts (e.g. was the end result different than what was planned, what would be done differently, etc.), so that efforts can continue to get real gains.

## 6.3 Opportunities for Partnering in Rehabilitation

It was agreed by interviewees that there is an important role for engaging/partnering with the public and/or groups in rehabilitation. It was generally felt that if people are engaged and educated about a site, they will want to be involved with its development. Community support can also assist in obtaining funding for projects. Finally, many respondents noted that the local community knows the area. With their input, the rehabilitation of each site can be optimized.

It was recognized that some pits and quarries have greater opportunities than others for partnering. For instance, an agricultural field, returned to agriculture, does not offer as much potential. However, if the land becomes a part of the community (e.g. recreational pond, or open space surrounded by residential), then the public might offer some additional perspectives regarding rehabilitation (e.g. shorelines, access, etc.).

Respondents identified the following types of engagement, and who natural partners/collaborators in rehabilitation efforts would be.

Suggested Engagement Activities

- Developing manuals;
- Development of rehabilitation programs for a pit or quarry, or portions of the site;
- Rehabilitation tours;
- Discussions as to what rehabilitation will entail;

Suggested Engagement Activities

- Discussion of potential conflicts and ways to remedy them;
- Seed collection and nurseries; and
- Practical rehabilitation – true and long term (e.g. developing amphibian habitat)

Suggested Partners

- ENGO's (environmental non-governmental organizations) such as Ducks Unlimited, Nature Conservancy of Canada, Bird Studies Canada, Tallgrass Ontario, recovery teams for species at risk, etc.;
- Interested community members, that could include environmental programs, research groups and birders, as well as more non-traditional groups such as book clubs or road maintenance groups;
- The Aggregate Forum (a group of ENGO's and Aggregate Industry representatives);
- Universities and other research institutions;
- Industry groups (OSSGA, CLRA, TOARC);
- MNR;
- Municipalities;
- Conservation Authorities;
- School classrooms;
- Other provincial ministries (e.g. MMAH staff play a significant role in developing policy to protect land for extraction, yet they are not as informed about the operating pits and quarries, including their rehabilitation); and
- Service Clubs (e.g. Boy Scouts). The scouting movement has a long association with many pit and quarry operators and has contributed to tree planting on many sites every year.

Establishing and maintaining these partners takes time, effort and money, but according to many contacts interviewed, it must be done in order to build relationships and educate one another on interests and goals.

## 6.4 Identification and Record Keeping of Rehabilitated Pits and Quarries

It is recognized that there is no protocol to identify the location of licenced pits and quarries, once they have been rehabilitated. As a result, most people are not aware that there are rehabilitated pits and quarries in their locales. Ironically, this can be viewed as positive feedback to the producer who completed the rehabilitation. The history of the site, and the pit or quarry itself, blends into the landscape.

There have been publications documenting the history of the industry such as From Pits to Playgrounds: Aggregate Extraction and Pit Rehabilitation in Toronto – A Historical Overview (Yundt and Augaitis, 1992), and these provide important guidance for future generations.

OSSGA has established a series of awards, one of which is the prestigious Bronze Plaque award. The Bronze Plaque was established in 1975 and is only awarded to sites to recognize outstanding examples of rehabilitation. These sites demonstrate rehabilitation that is compatible with surrounding land use, as well as outstanding site design and ongoing property management. The recognized pits and quarries provide opportunities for wildlife habitat, passive and active recreation, geological interpretation, botanical research and they showcase important cultural heritage features (OSSGA, About Aggregates #2). This ongoing historical record is also important. OSSGA has produced an information brochure on the Bronze Plaque Award and it is attached as Appendix A.

MNR will surrender a licence when the Inspector is satisfied rehabilitation has occurred in accordance with the ARA, the regulations, the site plan and the conditions of the licence. This includes contacting TOARC to ensure that all licence fees have been paid. Policy indicates that the licensee must submit a request in writing to the MNR and the Aggregate Inspector must conduct a site inspection with the licensee to confirm that all rehabilitation requirements have been met. If the rehabilitation work is satisfactory, a Notice of Inspection is completed and kept in the file, and a letter is sent to the licensee, advising them the MNR accepts the surrender of the licence.

However, in the review of the 50 surrendered licences, it was apparent that the final documentation of the site, including contact names and photographs varied from district to district. MNR policy is clear on the steps to be taken for surrender of a licence relative to compliance with the ARA, however, there is no additional requirement for documentation of the life of the pit or quarry and subsequent rehabilitation, and associated record keeping on a data base. As the mandate for Pits and Quarries falls under MNR, if they are not keeping track of this information, no one is. It would be relatively simple for Aggregate Resources Officers to fill out a form as part of the surrendering process, and have this information added to the data base established by this study. It was widely recognized by the contacts that there should be an improved historical record kept of when the site was operated, who operated it, what the material was used for and how much was extracted, and when it was rehabilitated. Further, there was a suggestion that it should be publicly available on a database. If the database is not continued for this purpose, other existing documents could include this information (e.g. MNR Land Use Policy or District Land Use Guideline mapping, Official Plans, Trail Guides, etc.)

There should be a complete data record from MNR at the time of licence surrender (including the development of a data collection form on the history of the site) and regular updating of a data base to historically document the sites that have been rehabilitated. It is imperative that there be a permanent record keeping of the extractive sites, accessible by the public, otherwise these sites will disappear, along with the history of their contribution to local communities.

In additional, there should be further discussion as to whether recognition is provided for quality rehabilitation. This includes signage on properties, awards issued by governments or ENGO's, and publications.

There has been precedent set by other industries that identify with signs either the history of the site (e.g. retired landfills), or what work is underway (e.g. Ducks Unlimited projects for wetland construction).

The question was posed to the contacts as to whether or not rehabilitated sites should be identified. Many did not feel a sign was necessary, but was a potential valid form of education and good marketing. It is also a form of documentation. Concepts of what the site will eventually look like could be good promotion and education for new sites. There was recognition that without proper documentation and identification, the next generation will not know what we have learned and the history of the sites we have learned from.

## 6.5 MNR Recommendations from their 2006 Report

MNR should continue fulfilling the recommendations in their 2006 report including:

- *Collaborate with key stakeholders and examine in detail the merits of a rehabilitation incentive system, including the re-introduction of the former rehabilitation security deposit system.*

- *The existing rehabilitation data does not allow MNR to accurately analyze the effectiveness and efficiency of the existing management of rehabilitation efforts across the province. The reports recommend changes to improve the reliability of the data including recommendations related to:*
  - *more education and training for industry;*
  - *establishing mechanisms for data sharing between TOARC and MNR;*
  - *the creation of base-line data;*
  - *the use of new technologies (i.e.. GIS technology, satellite imagery) to determine landscape changes (i.e. disturbed area) within licenced and/or permitted sites and to track those changes over time. A pilot project will be established for sites within the GTA, by April 1, 2007;*
  - *the feasibly of developing an electronic filing system for the compliance assessment reports and improving efficiencies to data management for new licence and permit applications and existing reporting requirements under the ARA (e.g. production, rehabilitation) by April 1, 2007; and*
  - *developing mechanisms by April 2007 to improve the accuracy of reported rehabilitation information including the merits of requiring licensees and permittees to annually report (i.e. rehabilitation report) on their compliance with respect to their rehabilitation requirements.*
- *Transparent public reporting plays a key role in driving the transition of companies, industries, and economies towards the ultimate goals of continuous improvement and sustainable development. This strategy should also increase industry awareness of their responsibilities and act as a deterrent to those poorly performing members of the aggregate industry* (MNR, Review of Aggregate Resources Act, 2006).

### 6.6 Industry Involvement

In the last year there has been development of a group of Industry members, OSSGA and ENGO's working together in positive discussions about aggregate management within the province of Ontario. These industry and ENGO collaborative discussions are a positive step and one that would be beneficial to continue to build upon. Certainly many of the recommendations within this report can be met through this kind of collaboration.

Appendix A

OSSGA About Aggregates #2

Bronze Plaque Award

OSSGA
ONTARIO STONE, SAND & GRAVEL ASSOCIATION

*Essential materials for building a strong Ontario*

# BRONZE PLAQUE AWARD

*The Bronze Plaque Award was established in 1975 as the most prestigious industry award presented by the Ontario Stone, Sand & Gravel Association (formerly the Aggregate Producer's Association of Ontario). It is reserved for sites that have become truly outstanding examples of the state-of-the-art in pit or quarry rehabilitation.*

*The first ever Bronze Plaque Award winner, the Royal Botanical Gardens in Hamilton, Ontario (1976), is a rehabilitated pit on the Niagara Escarpment.*

# RECREATIONAL BRONZE PLAQUE WINNERS

*Our late Prime Minister, the Right Honourable Pierre Elliot Trudeau, enjoys a dip at the St. Mary's Swimming Quarry, a Bronze Plaque Award (1983) winning site in St. Mary's, Ontario.*

*A popular water sports facility, Professor's Lake, Brampton, is a rehabilitated pit and a recipient of the Bronze Plaque Award (1989).*

Pits and quarries can be rehabilitated to a variety of recreational after uses. OSSGA Bronze Plaque Award winning sites include:

- *St. Mary's Swimming Quarry*
- *Hagersville Ball Park*
- *Professor's Lake, Brampton*
- *Wasaga Sands Golf Community*
- *McIntyre Creek Estates, Wasaga Beach*
- *Lakeland Estates, Ottawa*
- *Smythe Park, Toronto*

These sites combine residential and recreational uses. Smythe Park, for example, was once a gravel pit and now features a marshy environment for wild-life habitat, and facilities for swimming, baseball, and tennis.

## FROM PITS TO PLAYGROUNDS

*Hagersville Ball Park in Hagersville, Ontario, is a Bronze Plaque winner (1994). This recreational facility is a good example of a rehabilitated site adjacent to a working site where aggregate extraction continues. A working pit is in the background of this site.*

Bronze Plaque Award winning sites demonstrate:

- *Rehabilitation compatible with the surrounding landscape*
- *Outstanding site design and rehabilitation, and*
- *Outstanding ongoing site management*


*The Ontario Stone, Sand & Gravel Association's Bronze Plaque award (formerly the Aggregate Producers' Association of Ontario).*

*The Bronze Plaque (1987) is unveiled at Lakeland Estates, a recreational and residential development, following aggregate extraction in the Ottawa area.*

# ...GOLF COURSES

*Fore! Lining up for a shot at East Park Gardens, a rehabilitated pit and Bronze Plaque Award winner (1977), in London, Ontario.*

Golf courses are a popular after use for pits and quarries. Examples of Bronze Plaque Award Winning golf courses include:

- *East Park Gardens, London*
- *Oaks Golf Course, London*
- *Orchard View Golf Course, Leamington*
- *Peninsula Lakes Golf Club, Fonthill*
- *Wasaga Sands, Wasaga Beach*

Careful design and soil resources management are required to create a quality golf course from a pit or quarry.

*This aerial photograph shows the beginnings of the development of the Peninsula Lakes Golf Club, a Bronze Plaque (1986) site in Fonthill, Ontario. Extraction continues to the south.*

## VALUABLE COMMUNITY RESOURCES….

Bronze Plaque Award winning sites such as the *Royal Botanical Gardens* in Hamilton, *Erindale College (University of Toronto*) in Mississauga, the *University of Guelph Arboretum* in Guelph, and the *Don Valley Brick Works Park* in Toronto are all excellent educational resources to their host communities.

These rehabilitated pits and quarries provide opportunities for wildlife habitat, passive recreation, geological interpretation, botanical research and showcase important cultural heritage features.

*A rehabilitated pit in the University of Guelph Arboretum provides research opportunities for students (Bronze Plaque, 1996).*

*The Don Valley Brick Works Park received a Bronze Plaque in 2000 to commemorate the origins of this site as a quarry and its transformation into an outstanding natural environment and cultural heritage park for the citizens of the Greater Toronto Region. The quarry face in the background is considered an internationally significant geologic site by geologists around the world.*

*Extraction at the future site of Erindale College (U of T) in Mississauga (Circa: 1955).*

*Erindale College today is a buzzing community campus (Bronze Plaque, 1980).*

# BRONZE PLAQUE AWARD WINNING SITES

| NAME OF SITE | SITE USE | YEAR |
|---|---|---|
| Royal Botanical Gardens, Hamilton | Botanical Gardens | 1976 |
| East Park Gardens, London | Golf Course | 1977 |
| Smythe Park, Toronto | Recreation | 1977 |
| Erindale College, University of Toronto, Mississauga | Education/Recreation | 1980 |
| St. Mary's Swimming Quarry, St. Mary's | Swimming | 1983 |
| Orchard View Golf Course, Leamington | Golf Course | 1984 |
| Peninsula Lakes Golf Club, Fonthill | Golf Course | 1986 |
| Lakeland Estates, Ottawa | Recreation/Residential | 1987 |
| Professor's Lake, Brampton | Water Sports/Residential | 1989 |
| Hagersville Ball Park, Hagersville | Baseball Park | 1994 |
| Oaks Golf Course, London | Golf Course | 1995 |
| University of Guelph Arboretum, Guelph | Education/Research | 1996 |
| Wasaga Sands Golf Community & MacIntyre Creek Estates, Wasaga Beach | Recreation/Residential | 1998 |
| Don Valley Brick Works Park, Toronto | Natural Environment/Cultural Heritage/Interpretive | 2000 |
| Glen Major Management Tract, Uxbridge | Natural Environment/Recreation | 2003 |
| Wainfleet Wetlands Conservation Area, Niagara | Natural Environment/Education/Recreation | 2004 |
| Kerncliff Park, Burlington | Recreation | 2005 |

**Visit a Bronze Plaque site near you and see what the aggregate industry is doing to give back to their communities!**

Also available in the "About Aggregates" series:

1. Aggregates and the Law
2. Bronze Plaque Award Program
3. Rehabilitation of Pits and Quarries
4. Being a Good Neighbour
5. Importance of Aggregates
6. Geology and Aggregate Extraction
7. Controlled Blasting at Quarries
8. Groundwater in the Aggregate Industry
9. Management of Abandoned Aggregate Properties Program (MAAP)

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# CHAPTER 4

# SAROS PAPER 6 REHABILITATION

# TASK 1 - A REVIEW OF PROGRESSIVE REHABILITATION ON LICENCED PITS AND QUARRIES

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APPENDIX A

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List of Vegetation Communities by Individual Site

## 1.0 INTRODUCTION

The objective of Task 1 was to conduct a '*review of selected sites in existing licences for effectiveness of rehabilitation in the context of site specific, healthy ecosystem and healthy community objectives.*' This provides a rare opportunity to understand what kind of rehabilitation, and how much is ongoing in a small sample group.

## 2.0 BACKGROUND

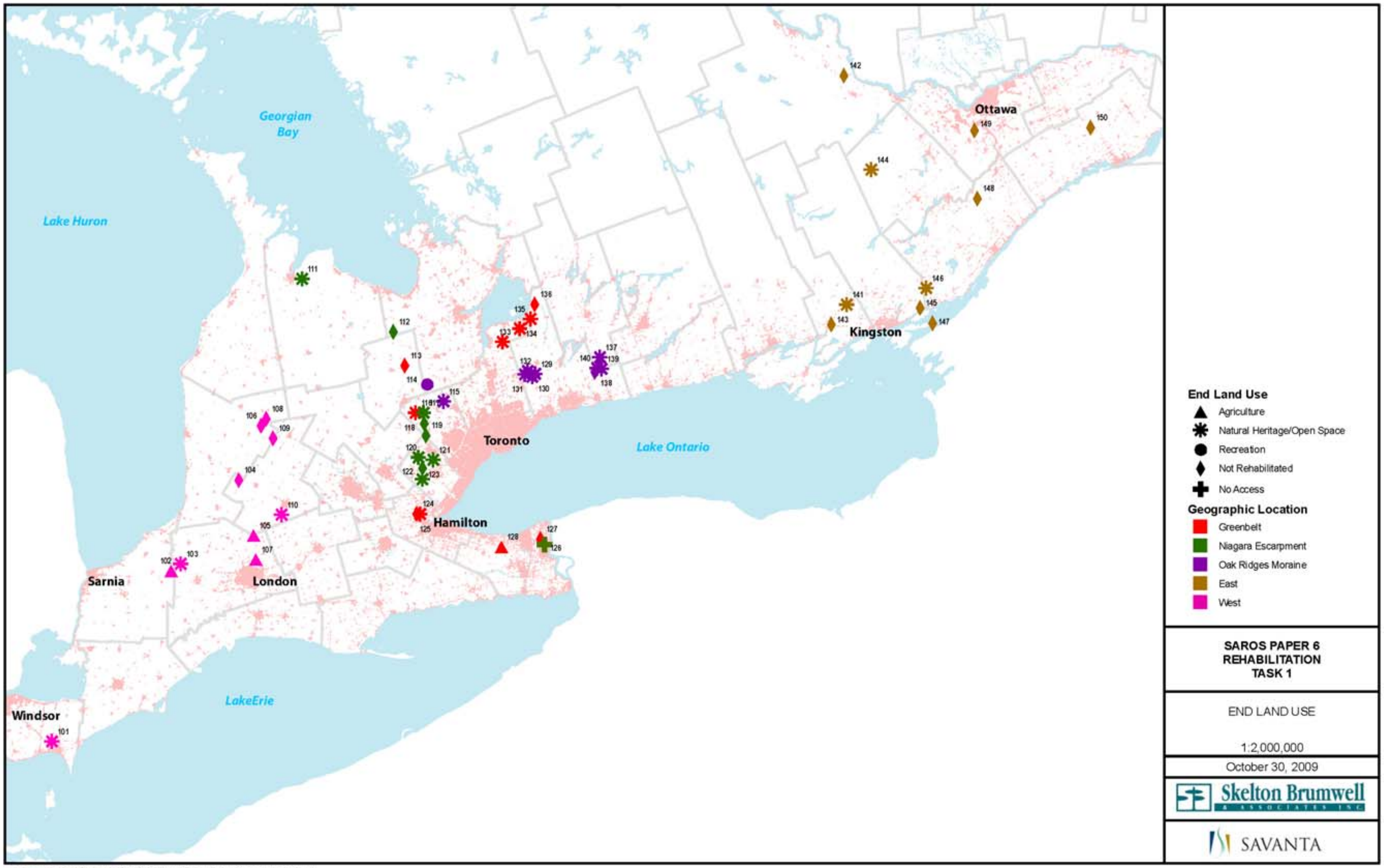
A total of 50 sites were selected in a blind-random fashion by the SAROS Advisory Committee out of a list of all licenced sites in southern Ontario. Advisory Committee members were instructed to select ten sites from a total of five geographic zones including:

1. Niagara Escarpment Plan Area;
2. Oak Ridges Moraine Conservation Plan Area;
3. Greenbelt Plan Area;
4. Eastern Ontario (Area 6) (East); and
5. Southwestern Ontario (Area 1) (West).

These sites were all assigned an identification number (101-150) and mapped (Figure 1). Preliminary research to gain a better understanding of the site characteristics included a review of individual Compliance Assessment Reports (CARs), site plans, and aerial photography.

These data were then integrated into a database and used as the basis for planning the field assessments, including clustering visits to both Task 1 and 2 sites to maximize efficiencies. Those sites where the CARs indicated that some level of rehabilitation had taken place were automatically included as part of the field assessments. For those sites where the CARs indicated that no progressive rehabilitation had taken place, confirmatory phone calls with site operators/owners were carried out to validate reported rehabilitation status. Any sites where site operators/owners indicated that any level of progressive rehabilitation had taken place were then added to the list for field assessments.

## Figure 1 – Distribution of Task 1 Sites



All field staff were assigned temporary ‘Aggregate Site Inspector Status’ by MNR to help facilitate access to the sites. Furthermore, for the most part phone calls were conducted approximately one week prior to proposed field visits for those identified as having some level of rehabilitation to notify site operators/owners and to answer any questions about the initiative. Field staff were instructed to contact operators/owners upon arrival at the sites to ensure full compliance with on-site safety protocol and also to confirm permission to access the site. In most cases, site operators/owners were responsive to the SAROS initiative and met the field staff on-site to highlight the rehabilitated portions of the site and to answer any questions.

## 2.1 Creation of the Database

All of the data collected, including photographs, were entered into the study database to facilitate the analysis. The database may be used in the future to continue to capture information at the time of licence surrender, and to facilitate additional research.

## 2.2 Field Assessment Protocol

Field assessments of the Task 1 sites for which any level of progressive rehabilitation had been confirmed were conducted between July 6th and August 14th, 2009 by Skelton Brumwell and Associates Inc. and Savanta Inc. staff. The following field assessment sheets were drafted and reviewed by MNR, with much of the gathered data focused on determining the extent to which Task 1 sites are achieving (or might achieve) site-specific healthy community or healthy ecosystem attributes (Appendix A):

1. Background Data;
2. Site Survey: General;
3. Owner/Operator Interview;
4. End Land Use
    1. Natural Heritage/Open Space;
    2. Recreation;
    3. Agriculture; and
    4. Commercial/Industrial/Residential Development.

Four end land use categories were used for the purposes of the field assessments: natural heritage/open space; recreation; agriculture; and commercial/industrial/residential development.

The approach to rehabilitation determined which of the following ‘end land use’ assessment sheets were completed by field staff on-site. Efforts were made to complete site operator/owner interviews on-site, although in some cases interviews were carried out by phone with a small number being incomplete due to difficulties in obtaining the information from the site owner/operators.

## 3.0 TASK 1 SITES: ASSESSMENT RESULTS

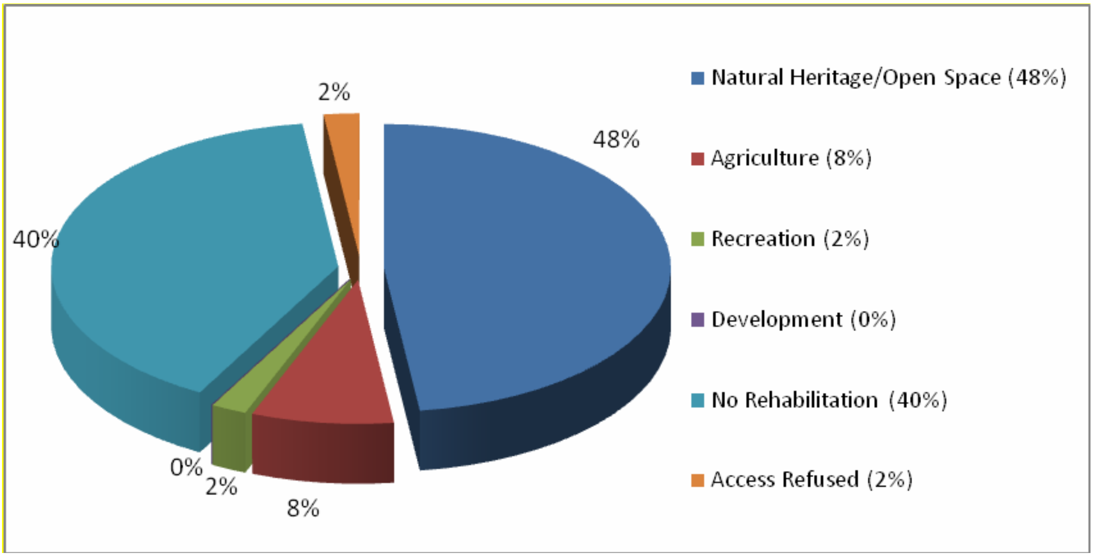
It was confirmed through review of the CAR’s and field investigation that 29 sites were undergoing progressive rehabilitation, 20 had not initiated progressive rehabilitation, and 1 site denied access so it could not be assessed. Field assessments for a total of 33 sites were undertaken to confirm the quantity and quality of rehabilitation. Rehabilitation was defined, consistent with S.1 (1) of the ARA as it relates to ‘progressive rehabilitation’, ‘final rehabilitation’, and ‘rehabilitate’. Particular emphasis was given to the definition of ‘progressive rehabilitation’ in terms of ensuring that rehabilitation is ‘done sequentially, within a reasonable time, in accordance with this Act, the regulations, the site plan, and the conditions of the licence or permit during that period that aggregate is being extracted…’.

Of the total of 50 sites, 16 are quarries and the remaining 35 are pits (one site was found to have both a pit and a quarry). Rehabilitation has not been initiated on 8 quarries and 12 pits, with one site not allowing access so it was unclear as to whether rehabilitation had been initiated. Given the relatively small sample size, caution must be exercised in drawing any definitive conclusions; however, some generalizations are offered in the discussion that follows.

Four end land use categories were used as part of the site assessments: (1) natural heritage/open space; (2) agriculture; (3) recreation; and, (4) commercial/industrial/residential development. It should be noted that in many cases those sites being rehabilitated to ‘open space’ had not yet determined a final end land use.

Figure 2 provides a breakdown of the end land uses of the 50 sites assessed as part of Task 1:

**Figure 2 – End Land Uses**




## 3.1 Natural Heritage/Open Space

For the natural heritage/open space field assessments, the Ecological Land Classification protocol was followed (Lee et al 1998). Soil samples were also taken at these sites for specialized analysis by the lab at the University of British Columbia, led by Dr. John Klironomos (formerly University of Guelph).

A total of 24 sites, of which 6 are quarries and 18 are pits, were found to be undertaking progressive rehabilitation with the end land use of natural heritage/open space. While in some cases, the end land use of natural heritage is clearly defined, for those sites being rehabilitated to open space, the end land use is sometimes still to be determined.

### 3.1.1 Progressive Rehabilitation

All of the sites undertaking progressive rehabilitation to natural heritage/open space were found to be following the general approaches outlined in the rehabilitation plan, with the most common being 'grading and seeding'. The majority of the seed mixes were determined to be widely available commercial seed mixes. Only five sites were found to be incorporating the planting of trees and shrubs as part of the rehabilitation plan (Table 1).

**Table 1 Natural Heritage/Open Space: Approaches to Rehabilitation**

| Site ID | Above or Below Water Pit or Quarry | Progressive Rehabilitation | Adjacent Natural Heritage Feature(s) | Adherence to Rehabilitation Plan |
|---|---|---|---|---|
| 101 | Above - and Below – Water Pit | Grading, Seeding | No | Yes |
| 103 | Above – Water Pit | Grading, Seeding | Yes | Yes |
| 110 | Below – Water Pit | Grading, Seeding | Yes | Yes |
| 111 | Below – Water Quarry | Grading, Seeding | Yes | Yes |
| 115 | Below – Water Pit | Grading, Seeding, Planting | Yes | Yes |
| 116 | Above – Water Pit | Grading, Seeding | Yes | Yes |
| 117 | Above- and Below- Water Pit | Grading[1] | Yes | Yes |
| 120 | Below – Water Quarry | Grading, Seeding, Planting | Yes | Yes |
| 121 | Below – Water Quarry | Grading, Seeding, Planting | Yes | Yes |
| 123 | Above – Water Pit | Grading, Seeding | Yes | Yes |
| 125 | Above - Water Quarry | Grading, Seeding | No | Yes |
| 129 | Above – Water Pit | Grading, Seeding | Yes | Yes |
| 130 | Above – Water Pit | Grading, Seeding | Yes | Yes |
| 131 | Above – Water Pit | Grading, Seeding | No | Yes |
| 132 | Above – Water Pit | Grading, Seeding | Yes | Yes |
| 133 | Below – Water Pit | Grading, Seeding, Planting | Yes | Yes |
| 134 | Above – Water Pit | Grading, Seeding | Yes | Yes |
| 135 | Above – Water Pit | Grading, Seeding | Yes | Yes |
| 137 | Above – Water Pit | Grading, Seeding | Yes | Yes |
| 139 | Below – Water Quarry | Grading, Seeding, Planting | Yes | Yes |
| 140 | Above – Water Quarry | Grading, Seeding | Yes | Yes |
| 141 | Above – Water Pit | Grading, Seeding | No | Yes |
| 144 | Above – Water Pit | Grading, Seeding | Yes | Yes |
| 146 | Above – Water Pit | Grading, Seeding | No | Yes |

[1] Seeding and clustered plantings proposed for Fall 2009 and Spring 2010

The only sites that specifically stated that natural heritage was the targeted final land use are: Sites 115, 117, 120, 121, and 140. The following are summary of the approaches to rehabilitation being adopted at those sites:

Site 115 has planted a range of woody species including: Red Pine, White Pine, White Spruce, Staghorn sumac, Black Walnut, Carolina Poplar, Red Oak, and Black Locust. With the exception of Carolina Poplar, these species are all native to Ontario. The topsoil is generally being applied immediately to areas under progressive rehabilitation to avoid double handling and also stockpiling. The ponds have been stocked with native fish species including large-mouth bass.

Site 117 is in the early stages of progressive rehabilitation such that only grading and seeding had been completed at the time of the assessment. However, the intent is to seed in the fall 2009 and then to plant with a range of native woody trees and shrubs beginning in Spring 2010, clustered to allow for a range of habitat types including some open areas that will succeed overtime to a forested landscape. This approach will also ensure full integration with the adjacent licence, and also with the surrounding landscape, including a provincially significant wetland.

Site 120 is experimenting with ‘pit and mound’ restoration to maximize diversity in microtopography and to create some seasonally inundated habitat features. Stones are being used across the site to further diversify the habitat, including the creation of hibernacula. A range of native species including: white cedar, white spruce, white pine, red oak, red osier dogwood, white birch, yellow birch, sugar maple, and alternate-leaved dogwood have been planted on the site. While earlier rehabilitation efforts used a more standard seed mix, attempts are now being made to use seed mixes with a greater range of species including native species.

Site 121 is planting a range of native trees and shrubs including: white pine, poplar, white spruce, eastern white cedar, silver maple, sugar maple, red oak, chinquapin oak, red osier dogwood, grey dogwood, highbush cranberry, and sumac. Monitoring at this site has confirmed the use of the new habitat by a range of wildlife including insects, amphibians, birds and various mammals.

Site 140 is in the early stages of progressive rehabilitation; however, the ultimate objective is to undertake the comprehensive rehabilitation of several adjoining licences with the end land use being natural heritage. This approach is discussed in greater detail in Task 5.

### 3.1.2 Vegetation Communities

Floristic inventories were conducted at all 24 sites, and a list of species by individual site is provided in Appendix B. A total of 271 plant species were recorded across the 24 sites, of which 76 (or 28%) are non-native and invasive. While it is not possible to determine which of these species were introduced through the seeding and which ones arrived passively to the site, some such as timothy, Kentucky bluegrass, bird's foot trefoil, field fescue, orchard grass, white sweet clover, red clover, tufted vetch, and trailing crown vetch are typically associated with commercial seed mixes. Table 2 provides a summary of the top 20 most abundant species encountered across the sites being rehabilitated to natural heritage/open space, with 75% of these species being non-native.

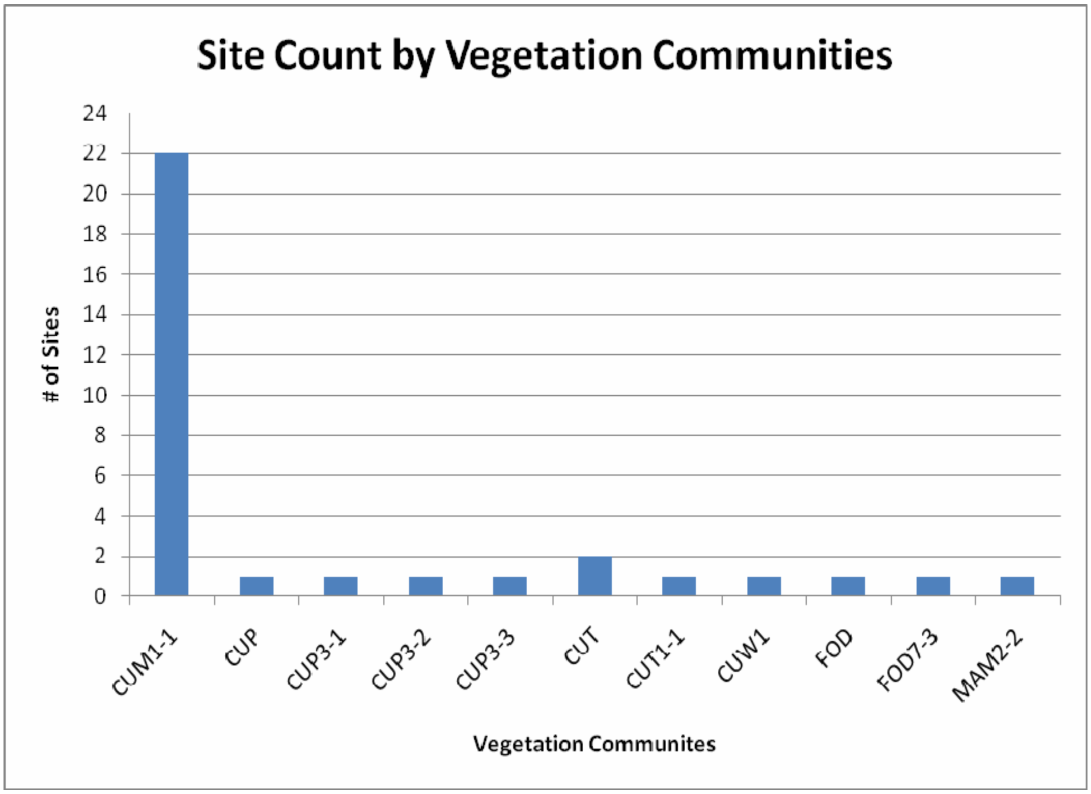
**Table 2 – Top 20 Most Abundant Species: Natural Heritage/Open Space**

| Species Code | Scientific Name | Common Name | Non-Native | Number of Sites |
|---|---|---|---|---|
| DAUCARO | *Daucus carota* | wild carrot | Yes | 23 |
| MELALBA | *Melilotus alba* | sweet white clover | Yes | 21 |
| VICCRAC | *Viccia cracca* | tufted vetch | Yes | 20 |
| ASCSYRI | *Asclepia syriaca* | common milkweed | No | 19 |
| TRIPRAT | *Trifolium pratense* | red clover | Yes | 18 |
| CHRLEUC | *Chrysanthemum leucanthemum* | ox-eye daisy | Yes | 17 |
| LOTCORN | *Lotus corniculatus* | bird's foot trefoil | Yes | 17 |
| POAPRPR | *Poa pratensis ssp. pratensis* | Kentucky blue grass | Yes | 17 |
| TAROFFI | *Taraxacum officinale* | common dandelion | Yes | 16 |
| PHLPRAT | *Phleum pratense* | timothy | Yes | 16 |
| MEDLUPU | *Medicago lupulina* | black medic | Yes | 16 |
| ERISTRI | *Erigeron strigosus* | lesser daisy fleabane | No | 15 |
| VERTHAP | *Verbascum thapsus* | common mullein | Yes | 15 |
| AMBARTE | *Ambrosia artemisifolia* | common ragweed | No | 15 |
| POACOMP | *Poa compressa* | Canada blue grass | No | 15 |
| SOLALAL | *Solidago altissima var. altissima* | tall goldenrod | No | 14 |
| BROININ | *Bromus inermis ssp. inermis* | smooth brome | Yes | 14 |
| ECHVULG | *Echium vulgare* | blueweed | Yes | 14 |
| SILVULG | *Silene vulgaris* | catchfly | Yes | 13 |
| ELYREPE | *Elymus repens* | quack grass | Yes | 13 |

The individual floristic species' makeup found across the Task 1 sites is reflected in the distribution of vegetation communities across the sites with the most common one being cultural meadow (CUM1-1) or old-field. In fact, this vegetation community was recorded at 22 sites

(Figure 3). Other vegetation communities encountered across the sites include: CUP (cultural plantation); CUT (cultural thicket); CUW (cultural woodland); FOD (deciduous forest); and, MAM (meadow marsh), with a full list of vegetation communities by individual site provided in Appendix C.

**Figure 3 – Vegetation Communities**



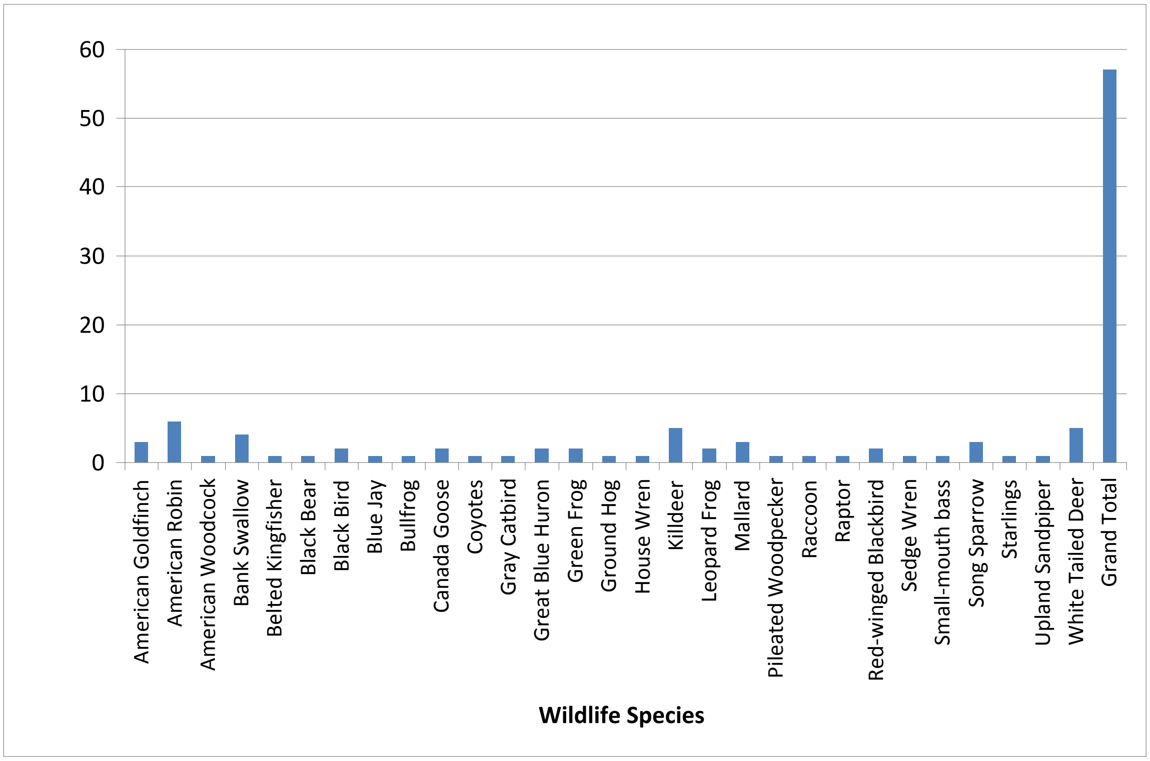

### 3.1.3 Wildlife Observations

Incidental observations of wildlife were carried out as part of the assessments of sites being rehabilitated to natural heritage/open space (Figure 4). Sedge wren and upland sandpiper are noteworthy observations at Sites 115 and 110, respectively. Upland sandpiper is a grassland species that has declined significantly in much of its range due to habitat loss and degradation. While it is not formally designated in Ontario, its probability of observation in the province has declined by 37% since the first breeding bird atlas (1981-85) (Cadman et al 2007).

Although sedge wren does have a broad range in Ontario and it is not formally designated, it does not tend to be found in large numbers at any one location and it is quite susceptible to habitat loss and degradation. The habitat for the sedge wren is typically wet sedge meadows, often with scattered shrubs; habitats that are not themselves very common. Sedge wrens tend to have low site fidelity, moving from one site to another for reasons likely related to water levels, although they may reoccur at sites even years apart (Cadman et al 2007).

Finally, bank swallows were observed at several sites and this species has been identified as one of three priority 'aerial insectivores' (i.e. eat insects while flying) in southern Ontario under the Ontario Landbird Conservation Plan: Lower Great Lakes/St. Lawrence Plain (Ontario Partners in Flight 2005).

**Figure 4 – Incidental Observations of Wildlife Species**



### 3.1.4 Soil Analysis

At 29 sites soil samples were collected from areas that had been graded and in most cases seeded (see Table 1) and sent to the lab of Dr. John Klironomos (UBC) for food web analysis, and levels of both pH and % organic matter. It was later determined that 5 of the sites were being rehabilitated to recreation and agriculture, and one site had only initiated grading in a small portion of the site. The focus of the soil analysis was to gain a better understanding of the soils relative to rehabilitation to open space/natural heritage end land uses.

The composition of the soil food web is a good indicator of soil quality. There are two main energy channels within the food web – (i) the bacterial channel and (ii) the fungal channel. Bacteria and fungi are groups of highly diverse microorganisms that are largely responsible for decomposition, and thus responsible for recycling dead organic materials and for the development of the soil ecosystem. The ratio of bacteria to fungi (B:F) in the soil is a particularly good indicator. Bacteria are smaller organisms that grow and reproduce very quickly, particularly in wet environments. They are more effective at utilizing simple sugars and inorganic nitrogen. In contrast, fungi are relatively larger, grow slower, and are more effective at utilizing complex carbohydrates (cellulose and lignin) and organic nitrogen. They are tolerant of very dry environments. Thus soils with high B:F ratios typically have faster, more open nutrient cycles and promote plants with fast growth rates (such as weedy herbaceous plants). Soils with low B:F ratios typically have slower, more closed nutrient cycles and promote slower-growing plants (such as woody perennials).

Bacterial and fungal abundance in the soils were measured and the abundance of other organisms associated with the bacterial and fungal food chains was extracted and measured (see below for specific groups of organisms).

**A) Bacterial Food Chain**

Bacteria

↓

Bacterial feeding nematodes

↓

Predatory nematodes

### B) Fungal Food Chain

Fungal feeding nematodes

↗ ↘

**Fungi** → Collembola → Predatory mites

↓

Fungal feeding nematodes

↓

Predatory nematodes

All abundance data was also analyzed using the food web model by De Ruiter et al. (1994) to determine the relative rate of nutrient cycling in the soil. Across the sites B:F (bacterial: fungal) ratios were found to range from 0.65 – 13.7, with 91% of sites containing a higher abundance of bacteria than fungi. By far, the soils at these sites are bacterial dominated. Furthermore the foodweb analyses showed nutrient cycling that was predominantly fast and open, requiring new inputs on a regular basis. Overall these results indicate that weedy plants are most likely to be successful at those sites (and will continue to be so), unless something is done to increase the fungal energy channel in the soils (such as adding soil amendments (e.g. wood mulch) that are low in available nutrients and high in carbon to nitrogen (C:N) ratios, as discussed in greater detail in Chapter 6.

The soil was further analyzed for the abundance of arbuscular mycorrhizal fungi (AMF), a group of mutualistic symbiotic fungi, that are important for the establishment, growth, reproduction, and survival of most native plants (alien invasive plants do not require this symbiosis to any great degree). AMF abundance ranged from 8-90 (on a possible range of 0-100), with only 17% of samples containing a score >50. This indicates a very disturbed mycorrhizal fungal network in these soils overall, and as a result it is unlikely that these developing ecosystems will easily support plants that are highly mycorrhizal dependent (including most plants found in late successional systems, plants that are rare and endangered, and also most native woody perennial species in North American temperate ecosystems). The composition and diversity of the AMF community was not analysed, but it is very likely that many fungal taxa are missing from those sites, considering their degraded state. Amendment with AMF inoculation may be recommended to help support plants that are more mycorrhizal dependent. All plants listed in Table 2 (Section 3.1.2) have a low requirement for mycorrhizas, so it is not surprising that they are so abundant.

The range in pH across the sites was found to be 5.7 - 7.8, which is considered quite high and will promote a bacterial dominated system. In general, fungi tend to prefer a lower pH. The % organic matter content ranged from 0.8 - 4% across the sites which is quite low, and compares with mature grasslands and forests that typically range from 4% - 10%. Management strategies that would increase the organic matter content would go a long way towards promoting the appropriate fungal dominated soil required for desirable plants to grow (e.g wood mulch), as discussed in greater detail in Chapter 6.

### 3.1.5 Adjacent Land Uses

Almost 80% of the sites being rehabilitated to natural heritage/open space have some type of natural heritage feature in the surrounding landscape (Table 1). As such, there is a 'surrounding seed source' that may overtime contribute to the recovery of these sites to natural habitat. In particular, sites 115, 117, 120, 121, and 140 may benefit from nearby natural heritage features in that they are being actively rehabilitated to natural heritage end land uses. It should be noted that because no surveys were undertaken in the surrounding lands, the species' makeup, hence the seed source, is not known. As noted in Chapters 6,7 and 9, while the surrounding vegetation is important, different site-specific environmental conditions will filter the regional species' pool enabling only a specific subset of species to establish themselves. For examples, as noted in Section 3.1.4, limitations in the soil fungal diversity will likely affect the full recovery of most of the Task 1 sites to certain habitats and associated complements of native species without additional intervention.

The potential rehabilitation of the Task 1 sites to natural heritage features will, in turn, contribute to overall natural cover and connectivity at the landscape scale. As discussed in greater detail in Chapters 6, 7, and 9, biodiversity at the landscape scale is almost as important a determinant of the long-term health of the ecosystem as the local species' makeup.

## 3.2 Agriculture

Four sites are being rehabilitated to agricultural land uses – Sites 102, 105, 107, and 128.

Site 102 is surrounded by agricultural lands, so rehabilitation to this end land use allows for full integration with the surrounding landscape. The pre-extraction soils were classified by the Canada Land Inventory Soil Capability for Agriculture as Class 3T with the limiting factor being topography, and it is expected that the rehabilitation will result in soils of Class 2 or better because of the improvement in topography (Proctor & Redfern Ltd, 1997).

Site 105 is surrounded by agricultural lands, so rehabilitation to this land use allows for seamless integration into the surrounding landscape.

Site 107 is surrounded by a combination of agricultural, light industrial, and recreational (golfcourse), but is generally compatible with the broader surrounding land uses. Both ripping and stone picking were undertaken at this site.

Site 128 is found on the Niagara Escarpment, within the Protected Countryside of the Greenbelt, and also within the Growth Plan for the Greater Golden Horseshoe. The surrounding lands are predominantly agricultural, so this end land use is compatible with the prevailing policies. Consistent with the science recommendations (see Chapter 6), a seed mix of mostly legumes has been applied to this site and left for several years prior to full rehabilitation of the site to vineyards.

### 3.3 Recreation

Site 114 is being rehabilitated to a public golf course, which required an amendment to the site plan that originally called for an agricultural end use. The site is in the early stages of rehabilitation and at this point has only been seeded. This site is located in the Oak Ridges Moraine Conservation Plan – Countryside designation, which allows for this land use.

### 3.4 Commercial/Industrial/Residential Development

No sites were being rehabilitated to commercial, industrial, or residential land uses.

## 4.0 HEALTHY ECOSYSTEM AND HEALTHY COMMUNITIES

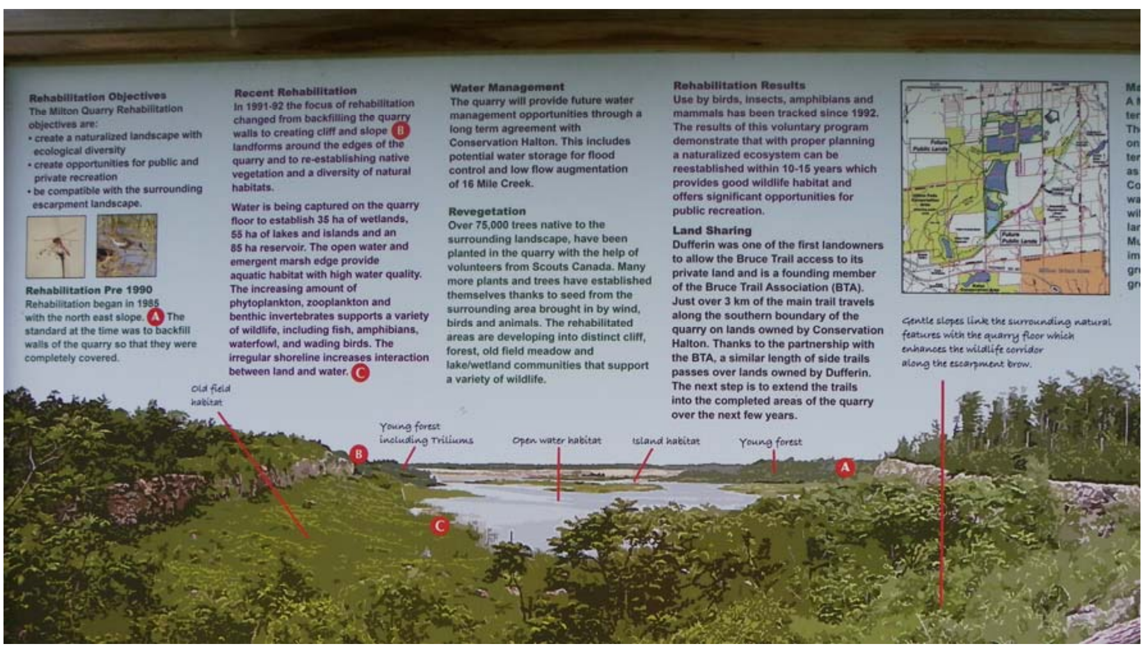
A more detailed discussion related to both ‘healthy ecosystems’ and ‘healthy communities’ is provided in Chapter 7; however, it is possible to correlate some of the findings of the Task 1 site assessments to these concepts. It is important to note that the Task 1 sites are under progressive rehabilitation and are generally early in their development, such that the contributions to both site-specific and broader landscape ‘healthy community’ and ‘healthy ecosystem’ objectives are expected to develop over time.

## 4.1 Healthy Communities

Attributes of healthy communities include a ‘diverse and vital economy’ and ‘adequate access to income, safety, work, and recreation for all’ (OHCC 2009). A number of the Task 1 sites contribute both directly and indirectly to the local economy in several ways including direct employment, but also by both financial and in-kind contributions.

For example, the owners of Sites 110 and 115 hold Open Houses to the public and for more specific groups such as boyscouts and schools, in addition to sponsoring various local sports teams. The Bruce Trail passes through inactive parts of Site 120, thereby contributing directly to fostering healthy and active lifestyles. An annual tree planting event is held at Site 121 during Earth Week. The site owners have also created a display board to educate individuals about the objectives of their rehabilitation. (See Figure 5)

**Figure 5 – Site 121: Display Board**




The extent to which the Task 1 sites may contribute to healthy communities will only be realised over time. Some of the sites such as Site 114, a golf course, will be open to the public and will contribute in terms of fostering healthier and active lifestyles through the provision of recreational open space.

## 4.2 Healthy Ecosystems

A number of the Task 1 sites have initiated progressive rehabilitation and are developing along a path that will contribute to the attributes associated with ‘healthy ecosystems’, in part because of the techniques implemented at the outset (e.g. the use of species that occur in the reference ecosystem, indigenous species, and suitable integration into the surrounding landscape). Specific examples include: Sites 115, 117, 120, 121, and 140 (discussed in greater detail in Section 3.1.1; Figure 6). In general these sites are examples of efforts working towards maximizing habitat diversity, using native species, and maximizing connectivity and integrating with surrounding natural heritage features. Notwithstanding these efforts, as noted in Section 3.1.4, and discussed further in Chapter 6, additional amendments and research may be necessary to ensure achievement of full rehabilitation of these systems to fully-functioning natural heritage features.

It should be noted that the prevailing approach to rehabilitation of the Task 1 sites using grading and seeding, solely, and without follow-up plantings of native species and potentially soil amendments, will do little to achieve either site-specific or landscape level objectives related to ‘healthy ecosystems’, and this is discussed in greater detail in Chapter 6. Additional measures including specific research aimed at addressing knowledge gaps, such as soil remediation measures, are likely necessary to achieve full and comprehensive site rehabilitation. Browning and Tan (2002) also determined that the traditional techniques of spreading overburden, grading, and seeding with a non-native seed mix only makes a difference in the short-term, and recommended that this approach be discontinued.

**Figure 6 – Site 120: Progressive Rehabilitation**

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

The Task 1 sites that have initiated progressive rehabilitation are generally fulfilling the requirements of the rehabilitation plans; however, as discussed in greater detail in Chapter 6, there are opportunities to improve some of these techniques and approaches in order to better achieve certain end use objectives and to optimize contributions to healthy communities and healthy ecosystems.

Progressive rehabilitation has not been initiated at twenty (40%) of the random sample of 50 sites. It is important to note that it was not within the scope of this study to investigate the reasons why progressive rehabilitation had not been initiated, nor to assess compliance issues. Chapter 6 of this report discusses progressive rehabilitation in general, the differences between pits and quarries, and introduces the operational logistics that dictate when and where progressive rehabilitation can occur.

Twelve of these sites (60%) are found in the East and West geographic zones (Figure 1). From some more qualitative observations and review of data collected, there seems to be a further pattern that suggests that more advanced and complex rehabilitation is being performed by mid to large sized producers and less so by the smaller site operators/owners. This is consistent with some of the public perceptions outlined in Chapter 3.

This points towards topics that merit further discussion, such as the economics associated with traditional rehabilitation approaches and a potential increased role for outreach and education related to progressive rehabilitation. A number of the interviewed producers expressed some frustration about the lack of information and guidance concerning approaches to rehabilitation, and also access to suitable native seed mixes.

The following are summary recommendations emerging from the assessment of those sites under progressive rehabilitation:

1. Forty percent of the sample sites have not initiated progressive rehabilitation. It was beyond the scope of this study to assess whether there is an opportunity to initiate rehabilitation on these sites. Therefore, it is recommended that the Aggregate Resources Officer meet with these operators to determine what, if any opportunities exist to commence progressive rehabilitation.
2. It was evident through the field visits with operators that many are lacking information on how to initiate and develop quality rehabilitation programs for their properties. As an immediate step, MNR should forward all available information on rehabilitation to all licensees (e.g. existing MNR papers/newsletters, MNR publications and other references within this report).
3. As recommended in other sections of this report, it would be useful to have a Rehabilitation Specialist within MNR Aggregates and Petroleum Section who could coordinate these activities as well as other needed rehabilitation initiatives.
4. The results of the floristic inventories at the 24 sites under rehabilitation to natural heritage/open space indicate the presence of a high number of non-native and in many cases invasive species. This combined with the site operator/owner interviews suggest that there is a heavy reliance on the use of commercial seed mixes in the approaches to rehabilitation of aggregate sites. There is a need for additional guidance, outreach and

education to ensure that more appropriate native seed mixes are used, and also that there are readily available supplies of suitable seed mixes. Associated with this is a need for applied research into the types and sequencing of native seed mixes to maximize successful rehabilitation to natural heritage/open space land uses.

5. The prevailing approach of limiting rehabilitation to grading and seeding at sites, in the absence of follow-up plantings with native species (and potentially soil amendments) will not contribute to successful achievement of ‘healthy ecosystems’ in the longer term. It is recommended that operators be educated and encouraged to put their money and efforts into more effective rehabilitation (e.g. variable grading, native seed mixes, diversity of native species, etc).
6. The incidental observations of wildlife suggest revealed that some of these sites provide habitat for a certain number of species that are relatively rare or at some level of decline in the province. There appear to be opportunities and an interest with some producers to create a greater diversity of habitat that will maximize benefits to wildlife; however, greater outreach and education and technical guidance is required.
7. The results of the soil sample analysis indicated that they are bacterial-dominated and that nutrient cycling is fast and open. Applied research aimed at soil amendments to increase carbon:nitrogen ratios, organic matter, and overall fungal diversity is recommended.

# APPENDIX A

## Field Assessment Sheets

| SAROS Paper No. 6 - REHABILITATION | |
|---|---|
| **Task 1 and 2** | **Background Data** |
| **Site Number** | |
| **Site Name** *e.g. Smith Pit* | |
| **Owners Name** | |
| Address | |
| Telephone | |
| email address | |
| Permission for Access | |
| **Location** | |
| County/Region | |
| Township/City | |
| Street Address | |
| Geographic Township | |
| Lot | |
| Concession | |
| Geology/Physiography (if known) | |
| **Historic data (Source)** | *Provide source for all information (e.g.ARA Site Plan, MNR correspondence)* |
| Licence Reference # | |
| Date of Surrender | |
| Pit or Quarry | |
| ARA Site Plan | |
| Licenced Area ha *e.g. 40 (ARA Site Plan)* | |
| Area to be extracted ha | |
| Rehabilitated Area ha | |
| CAR Report *e.g 2007, 2008 (owner)* | |
| Photos *e.g. 4 X 6 Prints (OSSGA)* | |
| Air Photos *e.g. 1971(MNR)* | |
| Written description *e.g. (OSSGA awards)* | |
| Maps *e.g. OP Schedule (County)* | |
| Development Plans *e.g. Plan of Sub'n (Twp)* | |

| SAROS Paper No. 6 - REHABILITATION | |
|---|---|
| **Task 1 and 2** | **Background Data** |
| **Site Number** | |
| **Other Information** | |
| Applicable Planning Policy<br>*e.g. ORM, NEC* | |
| Other<br>*e.g. Articles* | |
| Integration of Existing Road | |
| Integration of Unopened Road Allowance | |
| Integration with adjacent pit above water table | |
| Integration with adjecent pit below water table | |
| Comprehensive Rehabilitation  Plan | |
| | |

| SAROS Paper No. 6 - REHABILITATION | |
|---|---|
| **Task 1 and 2** | **General Site Survey Sheet** |
| **Site Number** | |
| **Site Name** *e.g. Smith Pit* | |
| Date | |
| Surveyor | |
| Total Site Area (ha) | |
| Observed Rehabilitated Area ha | |
| Area of backslopes (ha) | |
| Area of Pit Floor (ha) | |
| Existing Land Use *e.g. Residential subdivision/ golf course/ agricultural/ private open space* | |
| Buildings | |
| Access *e.g. Private road* | |
| Visibility *e.g. Visible to the public to the north* | |
| Vegetation *e.g. Naturalized/manicured, varied/uniform* | |
| Topography *e.g. Faces/floor are Flat/sloped/varied* | |
| Description of Pit/Quarry Water Features *e.g. Size, naturalized, stable shorelines* | |

| SAROS Paper No. 6 - REHABILITATION | |
|---|---|
| **Task 1 and 2** | **General Site Survey Sheet** |
| **Site Number** | |
| Description of Natural Water Features *e.g. Watercourse, pond* | |
| Adjacent Land Uses - General *e.g.rural/urban/forested* | |
| North | |
| South | |
| East | |
| West | |
| Photos taken *e.g. Adjacent property from north west corner of site* | |
| Comments *e.g. Integration with adjacent land uses, natural heritage features, etc.* | |

| SAROS Paper No. 6 - REHABILITATION | |
|---|---|
| **Task 1 and 2** | **Owner/Operator Interview** |
| **Site Number** | |
| **Site Name** *e.g. Smith Pit* | |
| Date | |
| Interviewer | |
| Owner/Operator | |
| Address | If different from Background Data Sheet |
| Telephone | If different from Background Data Sheet |
| email | If different from Background Data Sheet |
| Above/Below Water Table | |
| Age of Pit/Quarry | |
| Depth of extraction m | |
| Rehabilitated Area ha | |
| Date of rehabilitation | |
| **Type of rehabilitation** | |
| Ripping | |
| Grading | |
| Seeding | |
| Topsoil | |
| Fertilizer | |
| Tree Planting | |
| Final or progressive *(in specific area)* | |
| Other | |
| **Aim of rehabilitation** | |
| Agricultural | |

| | |
|---|---|
| Recreational *(golfcourse etc)* | |
| Natural Heritage *(describe)* | |
| Other | |
| **General condition of rehabilitation** *(if complete in an area)* | |
| Approx Survival Rate (%) | |
| Approx Percent reforested | |
| Planting distance/density | |
| Erosion | |
| **Source of planted materials** | |
| MNR | |
| Private Nursery | |
| Conservation Authority | |
| On-site transplantation *(specify from where )* | |
| Other | |
| **Type of plant stock** | |
| Bareroot | |
| Container | |
| Balled and burlapped | |
| Seedling | |
| Seed | |

| | |
|---|---|
| Plugs | |
| Other | |
| **List of species** | |
| Trees | |
| Shrubs | |
| Herbaceous | |
| **Agricultural** | |
| Type of crop | |
| Previous years crop and crop yield | |
| **Site Preparation** | |
| Overburden replaced (source) | |
| Depth of overburden | |
| Topsoil replaced *(source)* | |
| Length of time that topsoil was stored | |
| Depth of topsoil m | |
| Use of pond fines or plant byproducts | |
| Amendments added *(fertilizer, organic material)* | |
| Graded | |
| Equipment used | |
| **Planting techniques** | |
| Mechanical *(hired; staff; other)* | |

| | |
|---|---|
| Tree/shrub planting | |
| Manual *(hired; staff; other)* | |
| Seeding | |
| Tree/shrub planting | |
| Hydroseeding *(hired; staff; other)* | |
| **Hydrogeology** | |
| Depth of water table relative to rehabilitation | |
| Source of any surface water on-site | |
| **Maintenance Program** | |
| Personnel *(hired; contract; staff)* | |
| Description *(fertilizer; pruning; watering; mowing; staking; equipment; mulching; cocomats, etc)* | |
| **Rehabilitation Monitoring** | |
| Records of rehabilitation to-date | |
| On-site monitoring | |
| Applications for awards or awards received | |
| Press articles regarding rehabiltiation | |
| Conferences, workshop presentations re: | |
| **Socio-economic/cultural** | |
| Open houses or other to engage community | |

| | |
|---|---|
| Access to public allowed *(e.g. tours)* | |
| Corporate donations, event sponsorships, etc | |
| Proximity to adjacent communities | |
| Size of operation *(scale house, lunch room, etc)* | |
| Number of employees *(f/t vs p/t)* | |
| Longevity of employment | |
| Average commute distance for employees | |

| | A | B | C |
|---|---|---|---|
| 1 | **SAROS Paper No. 6 - REHABILITATION** | | |
| 2 | **Task 1** | **Detailed Site Survey: Agriculture** | |
| 3 | **Licence Number** | | |
| 4 | **Site Number** | | |
| 5 | **Site Name *e.g. Smith Pit*** | | |
| 6 | **Description of Rehabilitation** | **Area 1** | **Area 2** |
| 7 | Final Rehabilitated Area (ha) | | |
| 8 | Slopes (m) | | |
| 9 | Description of slopes (e.g. area, grade, simple or complex, uniformity) | | |
| 10 | Floor (ha) | | |
| 11 | **Surface Drainage** | | |
| 12 | P/Q Floor contoured to allow for surface drainage? | | |
| 13 | Soil Drainage (describe) | | |
| 14 | Outlet Drain Visible? Type? | | |
| 15 | Surface drainage adequate or are there areas of apparent seasonal standing water? | | |
| 16 | Depth to pit floor from existing grade (m) | | |
| 17 | Depth to watertable, where apparent (m) | | |
| 18 | **Soil Descriptions** (soil profile diagram)* Details where observable | | |
| 19 | Topsoil (y/n) | | |
| 20 | Depth of Topsoil (cm) (Ah/Ap) | | |
| 21 | Depth of B and C horizon | | |
| 22 | Subsoil and/or overburden (y/n) | | |
| 23 | Depth to top of S and/or O (cm) | | |

| | A | B | C |
|---|---|---|---|
| 1 | SAROS Paper No. 6 - REHABILITATION | | |
| 2 | **Task 1** | **Detailed Site Survey: Agriculture** | |
| 24 | Thickness of S and/or O layer (cm) | | |
| 25 | Soil Texture | | |
| 26 | Soil Compaction (y/n) (describe nature/extent) | | |
| 27 | **Rehabilitation Techniques Used (Where known)** | | |
| 28 | Pit floor(PF) – composition of PF (compacted glacial till/silty-clay | | |
| 29 | Topsoil Chisel ploughed & stone picked (y/n)? | | |
| 30 | Seeding Technique | | |
| 31 | **Crops** | | |
| 32 | Type of Crops - Specialty crops/row crops/cereals/forage/pasture/other? | | |
| 33 | Crop Type and Condition (vigour, colour, continuity & where observable, in comparison with nearby crops in non-rehabilitated settings) | | |
| 34 | Average height of crop (cm) | | |
| 35 | Even growth?; uneven growth and % of field in each? | | |
| 36 | **Description of Samples** | | |
| 37 | *One test pit dug per 10 ha.and soils described to depth of 1.2m according to Field Manual for Describing Soils in Ontario. Use OMAFRA and Ontario Soil Survey Reports for soil descriptions/classes and use 1:50,000 series CLI soil capability maps available fr+A14om OMAFRA for soil capability.<br>**Topsoil-The upper most layer of soil recognized by the dark colour due to the accumulation of organic matter. On agricultural lands it is the depth of cultivation which is usually 15 – 30 cm.;<br>**Subsoil**-This is the layer of soil immediately below the topsoil and may extend downwards for up to 1m. It consists of the B horizon and the upper C horizon. The subsoil is low in organic matter, often contains an accumulation of clay and may be well structured;<br>**Overburden**-The term is restricted to all material lying below the subsoil down to the surface of the aggregate deposit. It may be absent in many gravel pits. | | |

| | A | B | C |
|---|---|---|---|
| 1 | SAROS Paper No. 6 - REHABILITATION | | |
| 2 | **Task 1** | **Detailed Site Survey: Recreation** | |
| 3 | **Licence Number** | | |
| 4 | **Site Number** | | |
| 5 | **Site Name** ***e.g. Smith Pit*** | | |
| 6 | **Desription of Rehabilitation** | **Area 1** | **Area 2** |
| 7 | Rehabilitation End Use *e.g. Active recreation, passive recreation, waterbased* | | |
| 8 | Rehabilitated Areas *e.g. Slopes along north boundary, north part of floor* | | |
| 9 | Slopes *e.g. area, grade, uniformity* | | |
| 10 | Floor (ha) | | |
| 11 | Homogeneous/variable | | |
| 12 | Slopes (m) | | |
| 13 | Use of Overburden | | |
| 14 | Use of Topsoil | | |
| 15 | Seeding (grass, clover,etc.) | | |

| | A | B | C |
|---|---|---|---|
| 1 | SAROS Paper No. 6 - REHABILITATION | | |
| 2 | **Task 1** | **Detailed Site Survey: Recreation** | |
| 16 | Infrastucture<br>*e.g. Sports fields, trails, signage* | | |
| 17 | Maintenance | | |
| 18 | Comments | | |

| | A | B | C |
|---|---|---|---|
| 1 | SAROS Paper No. 6 - REHABILITATION | | |
| 2 | **Task 1** | **Detailed Site Survey: Commercial/Residential/Industrial** | |
| 3 | **Licence Number** | | |
| 4 | **Site Number** | | |
| 5 | **Site Name** ***e.g. Smith Pit*** | | |
| 6 | **Desription of Rehabilitation** | **Area 1** | **Area 2** |
| 7 | Rehabilitation End Use *e.g. Residential, Commercial, Industrial* | | |
| 8 | Rehabilitated Areas *e.g. Slopes along north boundary, north part of floor* | | |
| 9 | Slopes *e.g. area, grade, uniformity* | | |
| 10 | Floor (ha) | | |
| 11 | Homogeneous/variable | | |
| 12 | Slopes (m) | | |
| 13 | Floor (ha) | | |
| 14 | Use of Overburden | | |
| 15 | Use of Topsoil | | |
| 16 | Seeding | | |

| | A | B | C |
|---|---|---|---|
| 1 | SAROS Paper No. 6 - REHABILITATION | | |
| 2 | **Task 1** | **Detailed Site Survey: Commercial/Residential/Industrial** | |
| 17 | Infrastucture<br>*e.g. ditches, roads* | | |
| 18 | Maintenance | | |
| 19 | Comments | | |

Appendix B

List of Plant Species by Individual Site

# Task 1 - Plant Species by Site

| Site Number | 101 | | | | | | |
|---|---|---|---|---|---|---|---|
| Polygon | A | UTM Coordinate | 17 363350E 4661303N | Vegetation Type | Mixed Cultural Meadow | Vegetation Type Code | CUM1-1 |

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ABUTHEO | Herb | Abutilon theophrasti | Velvetleaf |
| AMAPOWE | Herb | Amaranthus powellii | Green Amaranth |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| AMBTRIF | Herb | Ambrosia trifida | Great Ragweed |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve�(Aster laevis var. l | Smooth Aster |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum� (As | Small White Aster (One-sided Aster) |
| BERINCA | Herb | Berteroa incana | Hoary False-alyssum |
| BROTECT | Graminoid | Bromus tectorum | Cheat Grass (Downy Chess) |
| CHEALAL | Herb | Chenopodium album var. album | Lamb's Quarters |
| CIRARVE | Herb | Cirsium arvense | Canada Thistle |
| CYCATRI | Herb | Cycloloma atriplicifolium | Winged Pigweed |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIGSANG | Graminoid | Digitaria sanguinalis | Large Crabgrass |
| DIPMURA | Herb | Diplotaxis muralis | Sand Rocket |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| ERACILI | Graminoid | Eragrostis cilianensis | Stink Grass |
| ERAPEPE | Graminoid | Eragrostis pectinacea var. pectinacea | Small Love Grass |
| ERUGALL | Herb | Erucastrum gallicum | French Rocket |
| LEPDENS | Herb | Lepidium densiflorum | Common Pepper-grass |
| LOLPERE | Graminoid | Lolium perenne | Perennial Rye Grass |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |

| | | | |
|---|---|---|---|
| PHRAUST | Graminoid | Phragmites australis | Common Reed |
| PHYHETE | Herb | Physalis heterophylla | Clammy Ground-cherry |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |
| POLCONV | Vine | Polygonum convolvulus | Black Bindweed |
| POLPERS | Herb | Polygonum persicaria | Lady's Thumb |
| SETPUMI | Graminoid | Setaria pumila | Yellow Foxtail |
| SISALTI | Herb | Sisymbrium altissimum | Tall Tumble-mustard |
| THLARVE | Herb | Thlaspi arvense | Field Penny-cress |
| TRIHYEL | Herb | Trifolium hybridum ssp. elegans | Alsike Clover |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VICTETR | Vine | Vicia tetrasperma | Sparrow Vetch |

**Polygon** B **UTM Coordinate** 17 363338E 4661193N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| AMBTRIF | Herb | Ambrosia trifida | Great Ragweed |
| ARESERP | Herb | Arenaria serpyllifolia | Thyme-leaf Sandwort |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTPIPI | Herb | Symphyotrichum pilosum var. pilosum | White Heath Aster (Hairy Aster) |
| BERINCA | Herb | Berteroa incana | Hoary False-alyssum |
| BROTECT | Graminoid | Bromus tectorum | Cheat Grass (Downy Chess) |
| CONARVE | Vine | Convolvulus arvensis | Field Bindweed |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIPMURA | Herb | Diplotaxis muralis | Sand Rocket |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| JUNVIRG | Tree | Juniperus virginiana | Eastern Red Cedar |
| LACSERR | Herb | Lactuca serriola | Prickly Lettuce |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |

| | | | |
|---|---|---|---|
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MELOFFI | Herb | Melilotus officinalis | Yellow Sweet-clover |
| PHRAUST | Graminoid | Phragmites australis | Common Reed |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| RHUTYPH | Shrub | Rhus typhina | Staghorn Sumac |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SALEXIG | Shrub | Salix exigua | Sandbar Willow |
| SISALTI | Herb | Sisymbrium altissimum | Tall Tumble-mustard |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| THLARVE | Herb | Thlaspi arvense | Field Penny-cress |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIREPE | Herb | Trifolium repens | White Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Site Number** 103

**Polygon** A **UTM Coordinate** 17 439800E 4765800N **Vegetation Type** Mixed Cultural meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| ARAARPU | Herb | Arabis arenicola var. pubescens | Arbis arenicola var. Pubescens |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BROTECT | Graminoid | Bromus tectorum | Cheat Grass (Downy Chess) |
| CIRVULG | Herb | Cirsium vulgare | Bull Thistle |
| CONARVE | Vine | Convolvulus arvensis | Field Bindweed |
| DAUCARO | Herb | Daucus carota | Wild Carrot |

| | | | |
|---|---|---|---|
| DIPFUSY | Herb | Dipsacus fullonum ssp. sylvestris | Common Teasel |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FESPRAT | Graminoid | Festuca pratensis | Meadow Fescue |
| GLEHEDE | Herb | Glechoma hederacea | Ground Ivy |
| HORJUJU | Graminoid | Hordeum jubatum ssp. jubatum | Squirrel-tail Grass |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MELOFFI | Herb | Melilotus officinalis | Yellow Sweet-clover |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIREPE | Herb | Trifolium repens | White Clover |

**Polygon** B **UTM Coordinate** 17 439800E 4765800N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| ARAARPU | Herb | Arabis arenicola var. pubescens | Arbis arenicola var. Pubescens |
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| ASTPIPI | Herb | Symphyotrichum pilosum var. pilosum | White Heath Aster (Hairy Aster) |
| BROTECT | Graminoid | Bromus tectorum | Cheat Grass (Downy Chess) |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIPFUSY | Herb | Dipsacus fullonum ssp. sylvestris | Common Teasel |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FESPRAT | Graminoid | Festuca pratensis | Meadow Fescue |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |

| | | | |
|---|---|---|---|
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MELOFFI | Herb | Melilotus officinalis | Yellow Sweet-clover |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SALEXIG | Shrub | Salix exigua | Sandbar Willow |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| SONARAR | Herb | Sonchus arvensis ssp. arvensis | Field Sow-thistle |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |

**Site Number** 110

**Polygon** A **UTM Coordinate** 17 499119E 4795088N **Vegetation Type** Dry-Moist Old Field Meadow Type **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGR__SP | Herb | Agrimonia sp | Agrimony Species |
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| CONARVE | Vine | Convolvulus arvensis | Field Bindweed |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| IMPCAPE | Herb | Impatiens capensis | Spotted Touch-me-not |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SIL__SP | Herb | Silene sp | Catchfly Species |

| | | | |
|---|---|---|---|
| SOL__SP | Herb | Solidago sp | Goldenrod Species |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

| Polygon | B | UTM Coordinate | 17 499051E 4795477N | Vegetation Type | Dry-Moist Old Field Meadow Type | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| CALCANA | Graminoid | Calamagrostis canadensis | Canada Blue-joint |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| CORSTOL | Shrub | Cornus stolonifera | Red-osier Dogwood |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| HIEAURA | Herb | Hieracium aurantiacum | Orange Hawkweed |
| IMPCAPE | Herb | Impatiens capensis | Spotted Touch-me-not |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MENARVE | Herb | Mentha arvensis | Wild Mint |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PHRAUST | Graminoid | Phragmites australis | Common Reed |
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |
| POPDEDE | Tree | Populus deltoides ssp. deltoides | Eastern Cottonwood |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SCICYPE | Sedge | Scirpus cyperinus | Wool Grass |
| SILLATI | Herb | Silene latifolia | Bladder Campion |
| SOL__SP | Herb | Solidago sp | Goldenrod Species |
| THUOCCI | Tree | Thuja occidentalis | Eastern White Cedar |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VICCARO | Vine | Vicia caroliniana | Carolina Vetch |

| Polygon | C | UTM Coordinate | 17 499160E 4795658N | Vegetation Type | Reed- canary Grass Mineral Meadow Marsh T | Vegetation Type Code | MAM2-2 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACERUBR | Tree | Acer rubrum | Red Maple |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| CIRVULG | Herb | Cirsium vulgare | Bull Thistle |
| CORSTOL | Shrub | Cornus stolonifera | Red-osier Dogwood |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| IMPCAPE | Herb | Impatiens capensis | Spotted Touch-me-not |
| PHRAUST | Graminoid | Phragmites australis | Common Reed |
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |
| POPDEDE | Tree | Populus deltoides ssp. deltoides | Eastern Cottonwood |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SOL__SP | Herb | Solidago sp | Goldenrod Species |
| THUOCCI | Tree | Thuja occidentalis | Eastern White Cedar |

**Site Number** 111

| Polygon | A | UTM Coordinate | 17 510829E 4934795N | Vegetation Type | Dry-Moist Old Field Meadow Type | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGRSTOL | Graminoid | Agrostis stolonifera | Spreading Bentgrass |
| ARCMIMI | Herb | Arctium minus ssp. minus | Common Burdock |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MENARVE | Herb | Mentha arvensis | Wild Mint |
| MITNUDA | Herb | Mitella nuda | Naked Mitrewort |

| | | | |
|---|---|---|---|
| PLAMAJO | Herb | Plantago major | Common Plantain |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SINARVE | Herb | Sinapis arvensis | Wild Mustard |
| SOL__SP | Herb | Solidago sp | Goldenrod Species |
| SOLDULC | Woody Vine | Solanum dulcamara | Bittersweet Nightshade |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Site Number** 115

**Polygon** A **UTM Coordinate** 17 595070E 4862672N **Vegetation Type** Fresh-Moist Willow Lowland Deciduous Fores **Vegetation Type Code** FOD7-3

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGRSTOL | Graminoid | Agrostis stolonifera | Spreading Bentgrass |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BETPAPY | Tree | Betula papyrifera | Paper Birch (White Birch) |
| CALCANA | Graminoid | Calamagrostis canadensis | Canada Blue-joint |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CLEVIRG | Vine | Clematis virginiana | Virgin's Bower |
| CORSTOL | Shrub | Cornus stolonifera | Red-osier Dogwood |
| EQUPRAT | Fern | Equisetum pratense | Meadow Horsetail |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| GLYGRAN | Graminoid | Glyceria grandis | American Manna Grass |
| IMPCAPE | Herb | Impatiens capensis | Spotted Touch-me-not |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MENARVE | Herb | Mentha arvensis | Wild Mint |
| ONOSENS | Fern | Onoclea sensibilis | Sensitive Fern |
| PICGLAU | Tree | Picea glauca | White Spruce |

| | | | |
|---|---|---|---|
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| RHUTYPH | Shrub | Rhus typhina | Staghorn Sumac |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOL__SP | Herb | Solidago sp | Goldenrod Species |
| THUOCCI | Tree | Thuja occidentalis | Eastern White Cedar |
| TYPLATI | Herb | Typha latifolia | Broad-leaved Cattail |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** B **UTM Coordinate** 17 595128E 4862510N **Vegetation Type** Dry-Moist Old Field Meadow Type **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| CALCANA | Graminoid | Calamagrostis canadensis | Canada Blue-joint |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| EQUPRAT | Fern | Equisetum pratense | Meadow Horsetail |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| GERBICK | Herb | Geranium bicknellii | Bicknell's Geranium |
| HIEAURA | Herb | Hieracium aurantiacum | Orange Hawkweed |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PINRESI | Tree | Pinus resinosa | Red Pine |
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| POTSIMP | Herb | Potentilla simplex | Common Cinquefoil |
| RANACRI | Herb | Ranunculus acris | Tall Buttercup |
| RUDHIRT | Herb | Rudbeckia hirta | Black-eyed Susan |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SILVULG | Herb | Silene vulgaris | Catchfly |

| | | | |
|---|---|---|---|
| SOL__SP | Herb | Solidago sp | Goldenrod Species |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** C **UTM Coordinate** 17 595002E 4862490N **Vegetation Type** NA **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| CALCANA | Graminoid | Calamagrostis canadensis | Canada Blue-joint |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| EQUPRAT | Fern | Equisetum pratense | Meadow Horsetail |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| GERBICK | Herb | Geranium bicknellii | Bicknell's Geranium |
| HIEAURA | Herb | Hieracium aurantiacum | Orange Hawkweed |
| IMPCAPE | Herb | Impatiens capensis | Spotted Touch-me-not |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PICGLAU | Tree | Picea glauca | White Spruce |
| PINRESI | Tree | Pinus resinosa | Red Pine |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| POTSIMP | Herb | Potentilla simplex | Common Cinquefoil |
| QUEVELU | Tree | Quercus velutina | Black Oak |
| RANACRI | Herb | Ranunculus acris | Tall Buttercup |
| RHUTYPH | Shrub | Rhus typhina | Staghorn Sumac |
| ROBPSEU | Tree | Robinia pseudo-acacia | Black Locust |
| RUDHIRT | Herb | Rudbeckia hirta | Black-eyed Susan |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOL__SP | Herb | Solidago sp | Goldenrod Species |

| | | | |
|---|---|---|---|
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

| Polygon | D | UTM Coordinate | 17 595229E 4862753N | Vegetation Type | Dry-Moist Old Field Meadow Type | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGRSTOL | Graminoid | Agrostis stolonifera | Spreading Bentgrass |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| CALCANA | Graminoid | Calamagrostis canadensis | Canada Blue-joint |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| EQUPRAT | Fern | Equisetum pratense | Meadow Horsetail |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| GERBICK | Herb | Geranium bicknellii | Bicknell's Geranium |
| HIEAURA | Herb | Hieracium aurantiacum | Orange Hawkweed |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| POTSIMP | Herb | Potentilla simplex | Common Cinquefoil |
| RANACRI | Herb | Ranunculus acris | Tall Buttercup |
| RHUTYPH | Shrub | Rhus typhina | Staghorn Sumac |
| RUDHIRT | Herb | Rudbeckia hirta | Black-eyed Susan |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOL__SP | Herb | Solidago sp | Goldenrod Species |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Site Number** 116

| Polygon | A | UTM Coordinate | 17 578989E 4856375N | Vegetation Type | Mixed Old Field Meadow | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |

| | | | |
|---|---|---|---|
| ARAGLAB | Herb | Arabis glabra | Tower-mustard |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CENJACE | Herb | Centaurea jacea | Brown Knapweed |
| CERFONT | Herb | Cerastium fontanum | Common Mouse-ear Chickweed |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CONARVE | Vine | Convolvulus arvensis | Field Bindweed |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| CYNROSS | Vine | Cynanchum rossicum | White Swallow-wort |
| DACGLOM | Graminoid | Dactylis glomerata | Orchard Grass |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LEOCACA | Herb | Leonurus cardiaca ssp. cardiaca | Motherwort |
| LEPDENS | Herb | Lepidium densiflorum | Common Pepper-grass |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| NEPCATA | Herb | Nepeta cataria | Catnip |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PARINSE | Woody Vine | Parthenocissus inserta | Thicket Creeper |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| SALEXIG | Shrub | Salix exigua | Sandbar Willow |

| | | | |
|---|---|---|---|
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| URTDIDI | Herb | Urtica dioica ssp. dioica | European Stinging Nettle |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

| **Polygon** | B | **UTM Coordinate** | 17 578907E 4856291N | **Vegetation Type** | Forb Cultural Meadow | **Vegetation Type Code** | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ARAGLAB | Herb | Arabis glabra | Tower-mustard |
| ARESERP | Herb | Arenaria serpyllifolia | Thyme-leaf Sandwort |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve(Aster laevis var. l | Smooth Aster |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum (As | Small White Aster (One-sided Aster) |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CAPBURS | Herb | Capsella bursa-pastoris | Common Shepherd's Purse |
| CARNULE | Herb | Carduus nutans ssp. Leiophyllus | Nodding Thistle |
| CERFONT | Herb | Cerastium fontanum | Common Mouse-ear Chickweed |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| CRETECT | Herb | Crepis tectorum | Narrow-leaved Hawk's Beard |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| EPIPARV | Herb | Epilobium parviflorum | Small-flowered Willow-herb |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |

| | | | |
|---|---|---|---|
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LACSERR | Herb | Lactuca serriola | Prickly Lettuce |
| LEPDENS | Herb | Lepidium densiflorum | Common Pepper-grass |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| NEPCATA | Herb | Nepeta cataria | Catnip |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POLCONV | Vine | Polygonum convolvulus | Black Bindweed |
| POTNORV | Herb | potentilla norvegica | Cinquefoil |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SALKALI | Herb | Salsola kali | Russian Thistle |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

| Polygon | C | UTM Coordinate | 17 578599E 4855765N | Vegetation Type | Mixed Old Field Cultural Meadow | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASTNOVA | Herb | Symphyotrichum novae-angliae� (Aster novae-angli | New England Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CENJACE | Herb | Centaurea jacea | Brown Knapweed |

| | | | |
|---|---|---|---|
| CERFONT | Herb | Cerastium fontanum | Common Mouse-ear Chickweed |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| CRETECT | Herb | Crepis tectorum | Narrow-leaved Hawk's Beard |
| CYNOFFI | Herb | Cynoglossum officinale | Common Hound's-tongue |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LEOCACA | Herb | Leonurus cardiaca ssp. cardiaca | Motherwort |
| LINVULG | Herb | Linaria vulgaris | Butter-and-eggs |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| PARINSE | Woody Vine | Parthenocissus inserta | Thicket Creeper |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTARGE | Herb | Potentilla argentea | Silvery Cinquefoil |
| POTNORV | Herb | potentilla norvegica | Cinquefoil |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| SOLJUNC | Herb | Solidago juncea | Early Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIHYEL | Herb | Trifolium hybridum ssp. elegans | Alsike Clover |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |

| | | | |
|---|---|---|---|
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

| Polygon | D | UTM Coordinate | 17 578754E 4855803N | Vegetation Type | Mixed Cultural Meadow | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ARAGLAB | Herb | Arabis glabra | Tower-mustard |
| ARESERP | Herb | Arenaria serpyllifolia | Thyme-leaf Sandwort |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CARCRIP | Herb | Carduus crispus | Curled Plumless-thistle |
| CENJACE | Herb | Centaurea jacea | Brown Knapweed |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| CRETECT | Herb | Crepis tectorum | Narrow-leaved Hawk's Beard |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| LACSERR | Herb | Lactuca serriola | Prickly Lettuce |
| LINVULG | Herb | Linaria vulgaris | Butter-and-eggs |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PASSATI | Herb | Pastinaca sativa | Wild Parsnip |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTARGE | Herb | Potentilla argentea | Silvery Cinquefoil |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| SILVULG | Herb | Silene vulgaris | Catchfly |

| | | | |
|---|---|---|---|
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Site Number** 120

**Polygon** A **UTM Coordinate** 17 580180E 4830375N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum (As | Small White Aster (One-sided Aster) |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve(Aster laevis var. l | Smooth Aster |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CLIVULG | Herb | Clinopodium vulgare | Wild Basil |
| DACGLOM | Graminoid | Dactylis glomerata | Orchard Grass |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ERIANNU | Herb | Erigeron annuus | Daisy Fleabane |
| FESPRAT | Graminoid | Festuca pratensis | Meadow Fescue |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |

| | | | |
|---|---|---|---|
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| PRUVUVU | Herb | Prunella vulgaris ssp. vulgaris | Selfheal |
| RHACATH | Shrub | Rhamnus cathartica | Common Buckthorn |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| SOLNENE | Herb | Solidago nemoralis ssp. nemoralis | Gray Goldenrod |
| TRAPRPR | Herb | Tragopogon pratensis ssp. pratensis | Meadow Goat's-beard |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** B **UTM Coordinate** 17 580127E 4830346N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACENEGU | Tree | Acer negundo | Manitoba Maple |
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum (As | Small White Aster (One-sided Aster) |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve(Aster laevis var. l | Smooth Aster |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| FRAAMER | Tree | Fraxinus americana | White Ash |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LINVULG | Herb | Linaria vulgaris | Butter-and-eggs |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| PARINSE | Woody Vine | Parthenocissus inserta | Thicket Creeper |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PINRESI | Tree | Pinus resinosa | Red Pine |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| PRUPENS | Shrub | Prunus pensylvanica | Pin Cherry |

| | | | |
|---|---|---|---|
| RHACATH | Shrub | Rhamnus cathartica | Common Buckthorn |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRAPRPR | Herb | Tragopogon pratensis ssp. pratensis | Meadow Goat's-beard |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** C **UTM Coordinate** 17 580128E 4830663N **Vegetation Type** Red Pine Plantation **Vegetation Type Code** CUP3-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| DACGLOM | Graminoid | Dactylis glomerata | Orchard Grass |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| EPIHELL | Herb | Epipactis helleborine | Helleborine |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| FESPRAT | Graminoid | Festuca pratensis | Meadow Fescue |
| FRAAMER | Tree | Fraxinus americana | White Ash |
| HIEPILO | Herb | Hieracium piloselloides | Glaucous King Devil |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LINVULG | Herb | Linaria vulgaris | Butter-and-eggs |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MONHYPO | Herb | Monotropa hypopithys | Pinesap |
| MONUNIP | Herb | Monotropa uniflora | Indian-pipe |
| PICGLAU | Tree | Picea glauca | White Spruce |
| PINRESI | Tree | Pinus resinosa | Red Pine |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |

| | | | |
|---|---|---|---|
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| PRUSERO | Tree | Prunus serotina | Black Cherry |
| QUEMACR | Tree | Quercus macrocarpa | Bur Oak |
| SALPETI | Shrub | Salix petiolaris | Slender Willow |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| THUOCCI | Tree | Thuja occidentalis | Eastern White Cedar |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VEROFFI | Herb | Veronica officinalis | Common Speedwell |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** D **UTM Coordinate** 17 580909E 4830515N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACESACC | Tree | Acer saccharinum | Silver Maple |
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| ASTPIPI | Herb | Symphyotrichum pilosum var. pilosum | White Heath Aster (Hairy Aster) |
| BETPAPY | Tree | Betula papyrifera | Paper Birch (White Birch) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CARNULE | Herb | Carduus nutans ssp. Leiophyllus | Nodding Thistle |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIAARME | Herb | Dianthus armeria | Deptford Pink |
| DIPFUSY | Herb | Dipsacus fullonum ssp. sylvestris | Common Teasel |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |

| | | | |
|---|---|---|---|
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| FRAAMER | Tree | Fraxinus americana | White Ash |
| GERROBE | Herb | Geranium robertianum | Herb Robert |
| LEPCAMP | Herb | Lepidium campestre | Field Cress |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| PRUPENS | Shrub | Prunus pensylvanica | Pin Cherry |
| QUERUBR | Tree | Quercus rubra | Red Oak |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| THUOCCI | Tree | Thuja occidentalis | Eastern White Cedar |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |
| ULMAMER | Tree | Ulmus americana | White Elm |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** E **UTM Coordinate** 17 580837E 4830784N **Vegetation Type** White Spruce Plantation **Vegetation Type Code** CUP

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|

| | | | |
|---|---|---|---|
| ACENEGU | Tree | Acer negundo | Manitoba Maple |
| EPIHELL | Herb | Epipactis helleborine | Helleborine |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| PARINSE | Woody Vine | Parthenocissus inserta | Thicket Creeper |
| PICGLAU | Tree | Picea glauca | White Spruce |
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |

**Site Number** 121

**Polygon** A **UTM Coordinate** 17 583829E 4819776N **Vegetation Type** Sumac Cultural Thicket CUT1-1 **Vegetation Type Code** CUT1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACESASA | Tree | Acer saccharum ssp. saccharum | Sugar Maple |
| ALLPETI | Herb | Alliaria petiolata | Garlic Mustard |
| ARCMIMI | Herb | Arctium minus ssp. minus | Common Burdock |
| CIRLUCA | Herb | Circaea lutetiana ssp. canadensis | Canada Enchanter's Nightshade |
| FRAAMER | Tree | Fraxinus americana | White Ash |
| GERROBE | Herb | Geranium robertianum | Herb Robert |
| GEUCANA | Herb | Geum canadense | White Avens |
| HESMATR | Herb | Hesperis matronalis | Dame's Rocket |
| MATSTPE | Fern | Matteuccia struthiopteris var. pensylvanica | Ostrich Fern |
| RHUTYPH | Shrub | Rhus typhina | Staghorn Sumac |
| ROSBLAN | Shrub | Rosa blanda | Smooth Wild Rose |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| RUBODOR | Shrub | Rubus odoratus | Purple Flowering Raspberry |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SAMRAPU | Shrub | Sambucus racemosa ssp. pubens | Red-berried Elderberry |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| SOLDULC | Woody Vine | Solanum dulcamara | Bittersweet Nightshade |
| SOLGIGA | Herb | Solidago gigantea | Giant Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

| Polygon | B | UTM Coordinate | 17 583902E 4819738N | Vegetation Type | Green Ash - Black Locust Cultural Thicket | Vegetation Type Code | CUT |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACESACC | Tree | Acer saccharinum | Silver Maple |
| ALLPETI | Herb | Alliaria petiolata | Garlic Mustard |
| ARCMIMI | Herb | Arctium minus ssp. minus | Common Burdock |
| CIRARVE | Herb | Cirsium arvense | Canada Thistle |
| CIRLUCA | Herb | Circaea lutetiana ssp. canadensis | Canada Enchanter's Nightshade |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| GEUALEP | Herb | Geum aleppicum | Yellow Avens |
| GEUCANA | Herb | Geum canadense | White Avens |
| HESMATR | Herb | Hesperis matronalis | Dame's Rocket |
| LONTATA | Shrub | Lonicera tatarica | Tartarian Honeysuckle |
| NEPCATA | Herb | Nepeta cataria | Catnip |
| PARINSE | Woody Vine | Parthenocissus inserta | Thicket Creeper |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| PINSTRO | Tree | Pinus strobus | Eastern White Pine |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| ROBPSEU | Tree | Robinia pseudo-acacia | Black Locust |
| ROSMULT | Shrub | Rosa multiflora | Multiflora Rose |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| SOLDULC | Woody Vine | Solanum dulcamara | Bittersweet Nightshade |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| THUOCCI | Tree | Thuja occidentalis | Eastern White Cedar |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |

| | | | |
|---|---|---|---|
| ULMAMER | Tree | Ulmus americana | White Elm |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VIOSORO | Herb | Viola sororia | Common Blue Violet |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Polygon** C **UTM Coordinate** 17 583934E 4819696N **Vegetation Type** Mixed Cultural Thicket **Vegetation Type Code** CUT

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACESASA | Tree | Acer saccharum ssp. saccharum | Sugar Maple |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| CLEVIRG | Vine | Clematis virginiana | Virgin's Bower |
| CORALTE | Shrub | Cornus alternifolia | Alternate-leaved Dogwood |
| CORSTOL | Shrub | Cornus stolonifera | Red-osier Dogwood |
| ELAANGU | Shrub | Elaeagnus angustifolia | Russian Olive |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| PARINSE | Woody Vine | Parthenocissus inserta | Thicket Creeper |
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| RANACRI | Herb | Ranunculus acris | Tall Buttercup |
| RHACATH | Shrub | Rhamnus cathartica | Common Buckthorn |
| RHUTYPH | Shrub | Rhus typhina | Staghorn Sumac |
| ROSMULT | Shrub | Rosa multiflora | Multiflora Rose |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| RUBOCCI | Shrub | Rubus occidentalis | Black Raspberry |
| RUBODOR | Shrub | Rubus odoratus | Purple Flowering Raspberry |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SALBEBB | Shrub | Salix bebbiana | Bebb's Willow |
| SALDISC | Shrub | Salix discolor | Pussy Willow |
| SALERIO | Shrub | Salix eriocephala | Woolly-headed Willow |

| | | | |
|---|---|---|---|
| SAMRAPU | Shrub | Sambucus racemosa ssp. pubens | Red-berried Elderberry |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| SOLDULC | Woody Vine | Solanum dulcamara | Bittersweet Nightshade |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| ULMPUMI | Tree | Ulmus pumila | Siberian Elm |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Polygon** D **UTM Coordinate** 17 584022E 4819596N **Vegetation Type** Old Field Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| DACGLOM | Graminoid | Dactylis glomerata | Orchard Grass |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIPFUSY | Herb | Dipsacus fullonum ssp. sylvestris | Common Teasel |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PARINSE | Woody Vine | Parthenocissus inserta | Thicket Creeper |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |

| | | | |
|---|---|---|---|
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| ROSMULT | Shrub | Rosa multiflora | Multiflora Rose |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Polygon** E **UTM Coordinate** 17 584229E 4819982N **Vegetation Type** Cultural Thicket **Vegetation Type Code** CUT

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACESASA | Tree | Acer saccharum ssp. saccharum | Sugar Maple |
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| APOANAN | Herb | Apocynum androsaemifolium ssp. androsaemifoliu | Spreading Dogbane |
| ASTCORD | Herb | Symphyotrichum cordifolium(Aster cordifolius) | Heart-leaf Aster |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| CLIVULG | Herb | Clinopodium vulgare | Wild Basil |
| CORAMOB | Shrub | Cornus amomum ssp. obliqua | Silky Dogwood |
| CORSTOL | Shrub | Cornus stolonifera | Red-osier Dogwood |
| CRA__SP | Shrub | Crataegus sp | Hawthorn Species |
| DACGLOM | Graminoid | Dactylis glomerata | Orchard Grass |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIAARME | Herb | Dianthus armeria | Deptford Pink |

| | | | |
|---|---|---|---|
| DIELONI | Shrub | Diervilla lonicera | Bush Honeysuckle |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FRAAMER | Tree | Fraxinus americana | White Ash |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MAIRARA | Herb | Maianthemum racemosum ssp. racemosum | False Solomon's Seal |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MELOFFI | Herb | Melilotus officinalis | Yellow Sweet-clover |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| PODPELT | Herb | Podophyllum peltatum | Mayapple |
| POPDEDE | Tree | Populus deltoides ssp. deltoides | Eastern Cottonwood |
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| PRUVUVU | Herb | Prunella vulgaris ssp. vulgaris | Selfheal |
| QUERUBR | Tree | Quercus rubra | Red Oak |
| RANACRI | Herb | Ranunculus acris | Tall Buttercup |
| RHUTYPH | Shrub | Rhus typhina | Staghorn Sumac |
| ROSBLAN | Shrub | Rosa blanda | Smooth Wild Rose |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| SALERIO | Shrub | Salix eriocephala | Woolly-headed Willow |
| SALEXIG | Shrub | Salix exigua | Sandbar Willow |

| | | | |
|---|---|---|---|
| SALPURP | Shrub | Salix purpurea | Purple Osier Willow |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| THUOCCI | Tree | Thuja occidentalis | Eastern White Cedar |
| TILAMER | Tree | Tilia americana | Basswood |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VIBLENT | Shrub | Viburnum lentago | Nannyberry |
| VIBTRIL | Shrub | Viburnum trilobum | Highbush Cranberry |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Polygon** F **UTM Coordinate** 17 584154E 4820049N **Vegetation Type** Willow-Dogwood Cultural Thicket **Vegetation Type Code** CUT

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACESASA | Tree | Acer saccharum ssp. saccharum | Sugar Maple |
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| ANEVIVI | Herb | Anemone virginiana var. virginiana | Thimbleweed |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| CAREBUR | Sedge | Carex eburnea | Ebony Sedge (Bristle-leaved Sedge) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CIRVULG | Herb | Cirsium vulgare | Bull Thistle |
| CORSTOL | Shrub | Cornus stolonifera | Red-osier Dogwood |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIPFUSY | Herb | Dipsacus fullonum ssp. sylvestris | Common Teasel |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| GEUALEP | Herb | Geum aleppicum | Yellow Avens |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |

| | | | |
|---|---|---|---|
| JUNDUDL | Rush | Juncus dudleyi | Dudley's Rush |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |
| POPDEDE | Tree | Populus deltoides ssp. deltoides | Eastern Cottonwood |
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| PRUVUVU | Herb | Prunella vulgaris ssp. vulgaris | Selfheal |
| RHUTYPH | Shrub | Rhus typhina | Staghorn Sumac |
| ROSMULT | Shrub | Rosa multiflora | Multiflora Rose |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| RUBODOR | Shrub | Rubus odoratus | Purple Flowering Raspberry |
| SALBEBB | Shrub | Salix bebbiana | Bebb's Willow |
| SALDISC | Shrub | Salix discolor | Pussy Willow |
| SALERIO | Shrub | Salix eriocephala | Woolly-headed Willow |
| SALPETI | Shrub | Salix petiolaris | Slender Willow |
| SCIATRO | Sedge | Scirpus atrovirens | Black Bulrush |
| SISMONT | Herb | Sisyrinchium montanum | Common Blue-eyed Grass |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| SOLNENE | Herb | Solidago nemoralis ssp. nemoralis | Gray Goldenrod |
| TRIAURE | Herb | Trifolium aureum | Yellow Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |
| VEROFFI | Herb | Veronica officinalis | Common Speedwell |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Polygon** G **UTM Coordinate** 17 583923E 4820398N **Vegetation Type** Fresh Black Locust Deciduous Forest **Vegetation Type Code** FOD

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ALLPETI | Herb | Alliaria petiolata | Garlic Mustard |
| ARCMIMI | Herb | Arctium minus ssp. minus | Common Burdock |
| CLEVIRG | Vine | Clematis virginiana | Virgin's Bower |

| | | | |
|---|---|---|---|
| CORVARI | Herb | Coronilla varia | Trailing Crown-vetch |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| GERROBE | Herb | Geranium robertianum | Herb Robert |
| GEUALEP | Herb | Geum aleppicum | Yellow Avens |
| GEUCANA | Herb | Geum canadense | White Avens |
| LIGVULG | Shrub | Ligustrum vulgare | Common Privet |
| LONTATA | Shrub | Lonicera tatarica | Tartarian Honeysuckle |
| PARINSE | Woody Vine | Parthenocissus inserta | Thicket Creeper |
| PASSATI | Herb | Pastinaca sativa | Wild Parsnip |
| PICGLAU | Tree | Picea glauca | White Spruce |
| PINSTRO | Tree | Pinus strobus | Eastern White Pine |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| RHACATH | Shrub | Rhamnus cathartica | Common Buckthorn |
| RHAFRAN | Shrub | Rhamnus frangula | Glossy Buckthorn |
| ROBPSEU | Tree | Robinia pseudo-acacia | Black Locust |
| ROS__SP | Shrub | Rosa sp | Rose Species |
| RUBALLE | Shrub | Rubus allegheniensis | Common Blackberry |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| RUBOCCI | Shrub | Rubus occidentalis | Black Raspberry |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SALFRAG | Tree | Salix fragilis | Crack Willow |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Polygon** H **UTM Coordinate** 17 583957E 4820432N **Vegetation Type** Old Field Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ARCMIMI | Herb | Arctium minus ssp. minus | Common Burdock |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |

| | | | |
|---|---|---|---|
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve�(Aster laevis var. l | Smooth Aster |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum� (As | Small White Aster (One-sided Aster) |
| ASTNOVA | Herb | Symphyotrichum novae-angliae� (Aster novae-angli | New England Aster |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| CIRARVE | Herb | Cirsium arvense | Canada Thistle |
| CIRVULG | Herb | Cirsium vulgare | Bull Thistle |
| CORVARI | Herb | Coronilla varia | Trailing Crown-vetch |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PASSATI | Herb | Pastinaca sativa | Wild Parsnip |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PICGLAU | Tree | Picea glauca | White Spruce |
| PINSTRO | Tree | Pinus strobus | Eastern White Pine |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |
| POPDEDE | Tree | Populus deltoides ssp. deltoides | Eastern Cottonwood |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| ROSMULT | Shrub | Rosa multiflora | Multiflora Rose |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

| Polygon | I | UTM Coordinate | 17 583474E 4820513N | Vegetation Type | Mixed Old Field Cultural Meadow | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum (As | Small White Aster (One-sided Aster) |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve (Aster laevis var. l | Smooth Aster |
| BROTECT | Graminoid | Bromus tectorum | Cheat Grass (Downy Chess) |
| CARCRIP | Herb | Carduus crispus | Curled Plumless-thistle |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| CIRARVE | Herb | Cirsium arvense | Canada Thistle |
| CONARVE | Vine | Convolvulus arvensis | Field Bindweed |
| CORVARI | Herb | Coronilla varia | Trailing Crown-vetch |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIPFUSY | Herb | Dipsacus fullonum ssp. sylvestris | Common Teasel |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERIANNU | Herb | Erigeron annuus | Daisy Fleabane |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| HORJUJU | Graminoid | Hordeum jubatum ssp. jubatum | Squirrel-tail Grass |
| LEPCAMP | Herb | Lepidium campestre | Field Cress |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| LYTSALI | Herb | Lythrum salicaria | Purple Loosestrife |
| MATPERF | Herb | Matricaria perforata | Scentless Chamomile |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MELOFFI | Herb | Melilotus officinalis | Yellow Sweet-clover |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PLAMAJO | Herb | Plantago major | Common Plantain |

| | | | |
|---|---|---|---|
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| PUCDIST | Graminoid | Puccinellia distans | Spreading Goose Grass |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Site Number** 123

**Polygon** A **UTM Coordinate** 17 583088E 4816556N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ARAARPU | Herb | Arabis arenicola var. pubescens | Arbis arenicola var. Pubescens |
| ATRPATU | Herb | Atriplex patula | Halberd-leaf Saltbush (Spearscale) |
| BARVULG | Herb | Barbarea vulgaris | Yellow Rocket (Common Wintercress) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CICINTY | Herb | Cichorium intybus | Chicory |
| CIRARVE | Herb | Cirsium arvense | Canada Thistle |
| CIRVULG | Herb | Cirsium vulgare | Bull Thistle |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| HORJUJU | Graminoid | Hordeum jubatum ssp. jubatum | Squirrel-tail Grass |
| LACSERR | Herb | Lactuca serriola | Prickly Lettuce |
| LEPCAMP | Herb | Lepidium campestre | Field Cress |
| LOLPERE | Graminoid | Lolium perenne | Perennial Rye Grass |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MATPERF | Herb | Matricaria perforata | Scentless Chamomile |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MELOFFI | Herb | Melilotus officinalis | Yellow Sweet-clover |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| PLAMAJO | Herb | Plantago major | Common Plantain |

| | | | |
|---|---|---|---|
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POLCONV | Vine | Polygonum convolvulus | Black Bindweed |
| POTNORV | Herb | potentilla norvegica | Cinquefoil |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| SONASAS | Herb | Sonchus asper ssp. asper | Spiny-leaved Sow-thistle |
| THLARVE | Herb | Thlaspi arvense | Field Penny-cress |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** B **UTM Coordinate** 17 583101E 4816593⍰⍰⍰⍰N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ARAARPU | Herb | Arabis arenicola var. pubescens | Arbis arenicola var. Pubescens |
| ASTNOVA | Herb | Symphyotrichum novae-angliae⍰ (Aster novae-angli | New England Aster |
| BARVULG | Herb | Barbarea vulgaris | Yellow Rocket (Common Wintercress) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| BROTECT | Graminoid | Bromus tectorum | Cheat Grass (Downy Chess) |
| CARCRIP | Herb | Carduus crispus | Curled Plumless-thistle |
| CICINTY | Herb | Cichorium intybus | Chicory |
| CIRARVE | Herb | Cirsium arvense | Canada Thistle |
| CIRVULG | Herb | Cirsium vulgare | Bull Thistle |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIPFUSY | Herb | Dipsacus fullonum ssp. sylvestris | Common Teasel |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| LEPCAMP | Herb | Lepidium campestre | Field Cress |
| LOLPERE | Graminoid | Lolium perenne | Perennial Rye Grass |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MATPERF | Herb | Matricaria perforata | Scentless Chamomile |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |

| | | | |
|---|---|---|---|
| MELOFFI | Herb | Melilotus officinalis | Yellow Sweet-clover |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SINARVE | Herb | Sinapis arvensis | Wild Mustard |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| SONARAR | Herb | Sonchus arvensis ssp. arvensis | Field Sow-thistle |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| THLARVE | Herb | Thlaspi arvense | Field Penny-cress |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** C **UTM Coordinate** 17 582903E 4816457N **Vegetation Type** Weed Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ANAARVE | Herb | Anagallis arvensis | Scarlet Pimpernel |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve(Aster laevis var. l | Smooth Aster |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum (As | Small White Aster (One-sided Aster) |
| ATRPATU | Herb | Atriplex patula | Halberd-leaf Saltbush (Spearscale) |
| BIDFRON | Herb | Bidens frondosa | Devil's Beggar-ticks |
| CHEALAL | Herb | Chenopodium album var. album | Lamb's Quarters |
| CIRARVE | Herb | Cirsium arvense | Canada Thistle |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| LACSERR | Herb | Lactuca serriola | Prickly Lettuce |
| LEPCAMP | Herb | Lepidium campestre | Field Cress |
| LOLPERE | Graminoid | Lolium perenne | Perennial Rye Grass |
| LYTSALI | Herb | Lythrum salicaria | Purple Loosestrife |

| | | | |
|---|---|---|---|
| MATPERF | Herb | Matricaria perforata | Scentless Chamomile |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POLAVIC | Herb | Polygonum aviculare | Common Knotweed |
| POLCONV | Vine | Polygonum convolvulus | Black Bindweed |
| POLLAPA | Herb | Polygonum lapathifolium | Pale Smartweed |
| POLPERS | Herb | Polygonum persicaria | Lady's Thumb |
| PUCDIST | Graminoid | Puccinellia distans | Spreading Goose Grass |
| SINARVE | Herb | Sinapis arvensis | Wild Mustard |
| SONARAR | Herb | Sonchus arvensis ssp. arvensis | Field Sow-thistle |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| THLARVE | Herb | Thlaspi arvense | Field Penny-cress |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |
| TYPANGU | Herb | Typha angustifolia | Narrow-leaved Cattail |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VICSATI | Vine | Vicia sativa | Spring Vetch |

**Polygon** D **UTM Coordinate** 17 583536E 4816727N **Vegetation Type** Crown Vetch Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACENEGU | Tree | Acer negundo | Manitoba Maple |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CARCRIP | Herb | Carduus crispus | Curled Plumless-thistle |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| CORVARI | Herb | Coronilla varia | Trailing Crown-vetch |
| DAUCARO | Herb | Daucus carota | Wild Carrot |

| | | | |
|---|---|---|---|
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POPDEDE | Tree | Populus deltoides ssp. deltoides | Eastern Cottonwood |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIHYEL | Herb | Trifolium hybridum ssp. elegans | Alsike Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |

**Site Number** 125

**Polygon** A **UTM Coordinate** Unknown **Vegetation Type** Dry-Moist Cultural Old Field Meadow Type **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACEPLAT | Tree | Acer platanoides | Norway Maple |
| ACESACC | Tree | Acer saccharinum | Silver Maple |
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| ALLPETI | Herb | Alliaria petiolata | Garlic Mustard |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ARCMIMI | Herb | Arctium minus ssp. minus | Common Burdock |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTCORD | Herb | Symphyotrichum cordifolium(Aster cordifolius) | Heart-leaf Aster |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve(Aster laevis var. l | Smooth Aster |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum (As | Small White Aster (One-sided Aster) |

| | | | |
|---|---|---|---|
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BARVULG | Herb | Barbarea vulgaris | Yellow Rocket (Common Wintercress) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CARNULE | Herb | Carduus nutans ssp. Leiophyllus | Nodding Thistle |
| CERARAR | Herb | Cerastium arvense ssp. arvense | Meadow Chickweed |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| CIRARVE | Herb | Cirsium arvense | Canada Thistle |
| CIRARVE | Herb | Cirsium arvense | Canada Thistle |
| CORAMOB | Shrub | Cornus amomum ssp. obliqua | Silky Dogwood |
| CRA__SP | Shrub | Crataegus sp | Hawthorn Species |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIPFUSY | Herb | Dipsacus fullonum ssp. sylvestris | Common Teasel |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| ERIANNU | Herb | Erigeron annuus | Daisy Fleabane |
| ERIPHPH | Herb | Erigeron philadelphicus ssp. philadelphicus | Philadelphia Fleabane |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LEOCACA | Herb | Leonurus cardiaca ssp. cardiaca | Motherwort |
| LEPCAMP | Herb | Lepidium campestre | Field Cress |
| LONTATA | Shrub | Lonicera tatarica | Tartarian Honeysuckle |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MALMOSC | Herb | Malva moschata | Musk Mallow |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |

| | | | |
|---|---|---|---|
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PARINSE | Woody Vine | Parthenocissus inserta | Thicket Creeper |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PHRAUST | Graminoid | Phragmites australis | Common Reed |
| PICPUNG | Tree | Picea Pungens | Colorado Spruce |
| PINRESI | Tree | Pinus resinosa | Red Pine |
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POPNIGR | Tree | Populus nigra | Lombardy Poplar |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| PRUVIVI | Shrub | Prunus virginiana ssp. virginiana | Choke Cherry |
| PRUVUVU | Herb | Prunella vulgaris ssp. vulgaris | Selfheal |
| RANBULB | Herb | Ranunculus bulbosus | Bulbous Buttercup |
| RANHICA | Herb | Ranunculus hispidus var. caricetorum | Swamp Buttercup |
| RHUGLAB | Shrub | Rhus glabra | Smooth Sumac |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| RUBOCCI | Shrub | Rubus occidentalis | Black Raspberry |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SALERIO | Shrub | Salix eriocephala | Woolly-headed Willow |
| SILLATI | Herb | Silene latifolia | Bladder Campion |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |

| | | | |
|---|---|---|---|
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| SONARAR | Herb | Sonchus arvensis ssp. arvensis | Field Sow-thistle |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| THUOCCI | Tree | Thuja occidentalis | Eastern White Cedar |
| TRAPRPR | Herb | Tragopogon pratensis ssp. pratensis | Meadow Goat's-beard |
| TRIHYEL | Herb | Trifolium hybridum ssp. elegans | Alsike Clover |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Polygon** B **UTM Coordinate** Unknown **Vegetation Type** Dry-Moist Cultural Old Field Meadow Type **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CIRARVE | Herb | Cirsium arvense | Canada Thistle |
| DIPFUSY | Herb | Dipsacus fullonum ssp. sylvestris | Common Teasel |
| ELAUMBE | Shrub | Elaeagnus umbellata | Autumn Olive |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERIANNU | Herb | Erigeron annuus | Daisy Fleabane |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |

| | | | |
|---|---|---|---|
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| ROBPSEU | Tree | Robinia pseudo-acacia | Black Locust |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| ULMPUMI | Tree | Ulmus pumila | Siberian Elm |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** C **UTM Coordinate** Unknown **Vegetation Type** Black Locust - Trembling Aspen Cultural Woo **Vegetation Type Code** CUW1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACENEGU | Tree | Acer negundo | Manitoba Maple |
| ALLPETI | Herb | Alliaria petiolata | Garlic Mustard |
| ARCMIMI | Herb | Arctium minus ssp. minus | Common Burdock |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve(Aster laevis var. l | Smooth Aster |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum (As | Small White Aster (One-sided Aster) |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| FRAPENN | Tree | Fraxinus pennsylvanica | Red Ash |
| GALAPAR | Herb | Galium aparine | Cleavers |
| HESMATR | Herb | Hesperis matronalis | Dame's Rocket |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| RHACATH | Shrub | Rhamnus cathartica | Common Buckthorn |
| ROBPSEU | Tree | Robinia pseudo-acacia | Black Locust |
| RUBOCCI | Shrub | Rubus occidentalis | Black Raspberry |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |

| Site Number | 129 | | | | | | |
|---|---|---|---|---|---|---|---|
| Polygon | A | UTM Coordinate | 17 648976E 4878577N | Vegetation Type | Forb Cultural Meadow | Vegetation Type Code | CUM1-1 |

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve(Aster laevis var. l | Smooth Aster |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum (As | Small White Aster (One-sided Aster) |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| CARNULE | Herb | Carduus nutans ssp. Leiophyllus | Nodding Thistle |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| DANSPIC | Graminoid | Danthonia spicata | Poverty Oat Grass |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| ERUGALL | Herb | Erucastrum gallicum | French Rocket |
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |
| FESPRAT | Graminoid | Festuca pratensis | Meadow Fescue |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| HIEPILO | Herb | Hieracium piloselloides | Glaucous King Devil |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MONFIST | Herb | Monarda fistulosa | Wild Bergamot |
| PANACAC | Graminoid | Panicum acuminatum var. acuminatum | Hairy Panic Grass |
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| PRUVUVU | Herb | Prunella vulgaris ssp. vulgaris | Selfheal |
| RHACATH | Shrub | Rhamnus cathartica | Common Buckthorn |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |

| | | | |
|---|---|---|---|
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| SOLNENE | Herb | Solidago nemoralis ssp. nemoralis | Gray Goldenrod |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** B **UTM Coordinate** 17 648974E 4878704N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACENEGU | Tree | Acer negundo | Manitoba Maple |
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| APOCANN | Herb | Apocynum cannabinum | Clasping-leaf Dogbane (Indian Hemp) |
| ARAGLAB | Herb | Arabis glabra | Tower-mustard |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| CYNROSS | Vine | Cynanchum rossicum | White Swallow-wort |
| DANSPIC | Graminoid | Danthonia spicata | Poverty Oat Grass |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |
| FESPRAT | Graminoid | Festuca pratensis | Meadow Fescue |
| HIEPILO | Herb | Hieracium piloselloides | Glaucous King Devil |
| LEPCAMP | Herb | Lepidium campestre | Field Cress |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MONFIST | Herb | Monarda fistulosa | Wild Bergamot |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PANACAC | Graminoid | Panicum acuminatum var. acuminatum | Hairy Panic Grass |

| | | | |
|---|---|---|---|
| PHYHETE | Herb | Physalis heterophylla | Clammy Ground-cherry |
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| PRUVUVU | Herb | Prunella vulgaris ssp. vulgaris | Selfheal |
| RHACATH | Shrub | Rhamnus cathartica | Common Buckthorn |
| RUDHIRT | Herb | Rudbeckia hirta | Black-eyed Susan |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** C **UTM Coordinate** 17 649132E 4878486N **Vegetation Type** Dry Scots Pine Cultural Thicket **Vegetation Type Code** CUT

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| ANECYLI | Herb | Anemone cylindrica | Long-fruited Anemone |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FESPRAT | Graminoid | Festuca pratensis | Meadow Fescue |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MONFIST | Herb | Monarda fistulosa | Wild Bergamot |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PHYHETE | Herb | Physalis heterophylla | Clammy Ground-cherry |
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |

| | | | |
|---|---|---|---|
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| RUDHIRT | Herb | Rudbeckia hirta | Black-eyed Susan |
| SOLNENE | Herb | Solidago nemoralis ssp. nemoralis | Gray Goldenrod |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Polygon** D **UTM Coordinate** 17 649055E 4878487N **Vegetation Type** Scots Pine Coniferous Forest **Vegetation Type Code**

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ELAANGU | Shrub | Elaeagnus angustifolia | Russian Olive |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| HIEPILO | Herb | Hieracium piloselloides | Glaucous King Devil |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LINVULG | Herb | Linaria vulgaris | Butter-and-eggs |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MAICANA | Herb | Maianthemum canadense | Canada Mayflower |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PHYHETE | Herb | Physalis heterophylla | Clammy Ground-cherry |
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| QUERUBR | Tree | Quercus rubra | Red Oak |
| RHACATH | Shrub | Rhamnus cathartica | Common Buckthorn |

| | | | |
|---|---|---|---|
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLNENE | Herb | Solidago nemoralis ssp. nemoralis | Gray Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Site Number** 130

**Polygon** A **UTM Coordinate** 17 648621E 4877859N **Vegetation Type** Forb Cultural Meadow **Vegetation Type Code**

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACENEGU | Tree | Acer negundo | Manitoba Maple |
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve(Aster laevis var. l | Smooth Aster |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum (As | Small White Aster (One-sided Aster) |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| CIRVULG | Herb | Cirsium vulgare | Bull Thistle |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PLARUGE | Herb | Plantago rugelii | Pale Plantain |

| | | | |
|---|---|---|---|
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POTANAN | Herb | Potentilla anserina ssp. anserina | Silverweed |
| POTNORV | Herb | potentilla norvegica | Cinquefoil |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERHAST | Herb | Verbena hastata | Blue Vervain |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |

**Polygon** B **UTM Coordinate** 17 648620E 4877800N **Vegetation Type** Forb Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACENEGU | Tree | Acer negundo | Manitoba Maple |
| ACIARVE | Herb | Acinos arvensis | Sping Savory (Mother-of-thyme) |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ARESERP | Herb | Arenaria serpyllifolia | Thyme-leaf Sandwort |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BROTECT | Graminoid | Bromus tectorum | Cheat Grass (Downy Chess) |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| CYNROSS | Vine | Cynanchum rossicum | White Swallow-wort |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| LEPDENS | Herb | Lepidium densiflorum | Common Pepper-grass |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |

| | | | |
|---|---|---|---|
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| SETPUMI | Graminoid | Setaria pumila | Yellow Foxtail |
| SILNOCT | Herb | Silene noctiflora | Night-flowering Catchfly |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SISALTI | Herb | Sisymbrium altissimum | Tall Tumble-mustard |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |

**Polygon** C **UTM Coordinate** 17 648629E 4877707N **Vegetation Type** Forb Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| APOCANN | Herb | Apocynum cannabinum | Clasping-leaf Dogbane (Indian Hemp) |
| ARESERP | Herb | Arenaria serpyllifolia | Thyme-leaf Sandwort |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHEALAL | Herb | Chenopodium album var. album | Lamb's Quarters |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| CRETECT | Herb | Crepis tectorum | Narrow-leaved Hawk's Beard |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LACSERR | Herb | Lactuca serriola | Prickly Lettuce |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELOFFI | Herb | Melilotus officinalis | Yellow Sweet-clover |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |

| | | | |
|---|---|---|---|
| PHYHETE | Herb | Physalis heterophylla | Clammy Ground-cherry |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POLCONV | Vine | Polygonum convolvulus | Black Bindweed |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |

| Polygon | D | UTM Coordinate | 17 648544E 4877647N | Vegetation Type | forb cultural meadow with planted scots pine | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ARESERP | Herb | Arenaria serpyllifolia | Thyme-leaf Sandwort |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHEALAL | Herb | Chenopodium album var. album | Lamb's Quarters |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| CYNROSS | Vine | Cynanchum rossicum | White Swallow-wort |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LINVULG | Herb | Linaria vulgaris | Butter-and-eggs |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PANCAPI | Graminoid | Panicum capillare | Witch Panic Grass |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |

| | | | |
|---|---|---|---|
| POLCONV | Vine | Polygonum convolvulus | Black Bindweed |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| SALKALI | Herb | Salsola kali | Russian Thistle |
| SECCERE | Graminoid | Secale cereale | Rye |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIREPE | Herb | Trifolium repens | White Clover |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Site Number** 131

**Polygon** A **UTM Coordinate** 17 643578E 4878610N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve(Aster laevis var. l | Smooth Aster |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum (As | Small White Aster (One-sided Aster) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CENSCAB | Herb | Centaurea scabiosa | Scabiose Knapweed |
| CIRVULG | Herb | Cirsium vulgare | Bull Thistle |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| GALMOLL | Herb | Galium mollugo | Smooth Bedstraw |

| | | | |
|---|---|---|---|
| HORJUJU | Graminoid | Hordeum jubatum ssp. jubatum | Squirrel-tail Grass |
| LOLPERE | Graminoid | Lolium perenne | Perennial Rye Grass |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TRIHYEL | Herb | Trifolium hybridum ssp. elegans | Alsike Clover |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** B **UTM Coordinate** 17 643645E 4878627N **Vegetation Type** (Pioneer) Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACENEGU | Tree | Acer negundo | Manitoba Maple |
| ACIARVE | Herb | Acinos arvensis | Sping Savory (Mother-of-thyme) |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CENSCAB | Herb | Centaurea scabiosa | Scabiose Knapweed |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CICINTY | Herb | Cichorium intybus | Chicory |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| ERUGALL | Herb | Erucastrum gallicum | French Rocket |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |

| | | | |
|---|---|---|---|
| GALMOLL | Herb | Galium mollugo | Smooth Bedstraw |
| HORJUJU | Graminoid | Hordeum jubatum ssp. jubatum | Squirrel-tail Grass |
| LOLPERE | Graminoid | Lolium perenne | Perennial Rye Grass |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PANCAPI | Graminoid | Panicum capillare | Witch Panic Grass |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| SONARAR | Herb | Sonchus arvensis ssp. arvensis | Field Sow-thistle |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** C **UTM Coordinate** 17 643785E 4878631N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CENSCAB | Herb | Centaurea scabiosa | Scabiose Knapweed |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |

| | | | |
|---|---|---|---|
| FESPRAT | Graminoid | Festuca pratensis | Meadow Fescue |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| HIEPILO | Herb | Hieracium piloselloides | Glaucous King Devil |
| LOLPERE | Graminoid | Lolium perenne | Perennial Rye Grass |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MELOFFI | Herb | Melilotus officinalis | Yellow Sweet-clover |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PANCAPI | Graminoid | Panicum capillare | Witch Panic Grass |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PHYHETE | Herb | Physalis heterophylla | Clammy Ground-cherry |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POLPERS | Herb | Polygonum persicaria | Lady's Thumb |
| SILANTI | Herb | Silene antirrhina | Sleepy Catchfly |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIHYEL | Herb | Trifolium hybridum ssp. elegans | Alsike Clover |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Site Number** 132

**Polygon** A **UTM Coordinate** 17 644945E 4880450N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ANECYLI | Herb | Anemone cylindrica | Long-fruited Anemone |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |

| | | | |
|---|---|---|---|
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CENSCAB | Herb | Centaurea scabiosa | Scabiose Knapweed |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PARINSE | Woody Vine | Parthenocissus inserta | Thicket Creeper |
| PHYHETE | Herb | Physalis heterophylla | Clammy Ground-cherry |
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| PRUPENS | Shrub | Prunus pensylvanica | Pin Cherry |
| PRUVIVI | Shrub | Prunus virginiana ssp. virginiana | Choke Cherry |
| RHURARY | Shrub | Rhus radicans ssp. rydbergii | Western Poison-ivy |
| RUDHIRT | Herb | Rudbeckia hirta | Black-eyed Susan |
| SAPOFFI | Herb | Saponaria officinalis | Bouncing Bet |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

| Polygon | B | UTM Coordinate | 17644800E 4880410N | Vegetation Type | Mixed Meadow with Scots Pine establishment | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACESASA | Tree | Acer saccharum ssp. saccharum | Sugar Maple |
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| ANECYLI | Herb | Anemone cylindrica | Long-fruited Anemone |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTERER | Herb | Symphyotrichum ericoides var. ericoides (Aster eri | White Heath Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CENSCAB | Herb | Centaurea scabiosa | Scabiose Knapweed |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |
| FRAAMER | Tree | Fraxinus americana | White Ash |
| FRAVEAM | Herb | Fragaria vesca ssp. americana | Woodland Strawberry |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PHYHETE | Herb | Physalis heterophylla | Clammy Ground-cherry |
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| PRUPENS | Shrub | Prunus pensylvanica | Pin Cherry |
| PRUVIVI | Shrub | Prunus virginiana ssp. virginiana | Choke Cherry |
| RHURARY | Shrub | Rhus radicans ssp. rydbergii | Western Poison-ivy |
| RIBOXYA | Shrub | Ribes oxyacanthoides | Bristly Wild Gooseberry |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| RUDHIRT | Herb | Rudbeckia hirta | Black-eyed Susan |
| SAPOFFI | Herb | Saponaria officinalis | Bouncing Bet |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |

| | | | |
|---|---|---|---|
| SOLNENE | Herb | Solidago nemoralis ssp. nemoralis | Gray Goldenrod |
| TRAPRPR | Herb | Tragopogon pratensis ssp. pratensis | Meadow Goat's-beard |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Site Number** 133

**Polygon** A **UTM Coordinate** 17 630810E 4898340N **Vegetation Type** Forb Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| DACGLOM | Graminoid | Dactylis glomerata | Orchard Grass |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FESPRAT | Graminoid | Festuca pratensis | Meadow Fescue |
| JUNVIRG | Tree | Juniperus virginiana | Eastern Red Cedar |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MELOFFI | Herb | Melilotus officinalis | Yellow Sweet-clover |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| SALBEBB | Shrub | Salix bebbiana | Bebb's Willow |
| SALEXIG | Shrub | Salix exigua | Sandbar Willow |

| | | | |
|---|---|---|---|
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Polygon** B **UTM Coordinate** 17 630810E 4898340N **Vegetation Type** Forb Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CONARVE | Vine | Convolvulus arvensis | Field Bindweed |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MELOFFI | Herb | Melilotus officinalis | Yellow Sweet-clover |
| PLALANC | Herb | Plantago lanceolata | Ribgrass |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SILLATI | Herb | Silene latifolia | Bladder Campion |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SISALTI | Herb | Sisymbrium altissimum | Tall Tumble-mustard |

| | | | |
|---|---|---|---|
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Polygon** D **UTM Coordinate** 17 630810E 4898340N **Vegetation Type** Scots Pine Plantation **Vegetation Type Code** CUP3-3

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ANEVIVI | Herb | Anemone virginiana var. virginiana | Thimbleweed |
| CERFONT | Herb | Cerastium fontanum | Common Mouse-ear Chickweed |
| DACGLOM | Graminoid | Dactylis glomerata | Orchard Grass |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| EQUARVE | Fern | Equisetum arvense | Field Horsetail |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIHYEL | Herb | Trifolium hybridum ssp. elegans | Alsike Clover |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Site Number** 134

**Polygon** A **UTM Coordinate** 17 640301E 4905536N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| ACIARVE | Herb | Acinos arvensis | Sping Savory (Mother-of-thyme) |

| | | | |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| AME__SP | Shrub | Amelanchier sp | Serviceberry Species |
| APOCANN | Herb | Apocynum cannabinum | Clasping-leaf Dogbane (Indian Hemp) |
| AQUCANA | Herb | Aquilegia canadensis | Wild Columbine |
| ARESERP | Herb | Arenaria serpyllifolia | Thyme-leaf Sandwort |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BETPAPY | Tree | Betula papyrifera | Paper Birch (White Birch) |
| CARTENE | Sedge | Carex tenera | Slender Straw Sedge |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| DACGLOM | Graminoid | Dactylis glomerata | Orchard Grass |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIAARME | Herb | Dianthus armeria | Deptford Pink |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LEPDENS | Herb | Lepidium densiflorum | Common Pepper-grass |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| RHURANE | Woody Vine | Rhus radicans ssp. negundo | Climbing Poison-ivy |
| RHUTYPH | Shrub | Rhus typhina | Staghorn Sumac |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |

| | | | |
|---|---|---|---|
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIREPE | Herb | Trifolium repens | White Clover |
| VERSESE | Herb | Veronica serpyllifolia ssp. serpyllifolia | Thyme-leaved Speedwell |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VICTETR | Vine | Vicia tetrasperma | Sparrow Vetch |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Polygon** B **UTM Coordinate** 17 640390E 4905570N **Vegetation Type** Goldenrod Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| ACIARVE | Herb | Acinos arvensis | Sping Savory (Mother-of-thyme) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTNOVA | Herb | Symphyotrichum novae-angliae (Aster novae-angli | New England Aster |
| BETPAPY | Tree | Betula papyrifera | Paper Birch (White Birch) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| DIAARME | Herb | Dianthus armeria | Deptford Pink |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| GEUALEP | Herb | Geum aleppicum | Yellow Avens |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| RHURANE | Woody Vine | Rhus radicans ssp. negundo | Climbing Poison-ivy |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |

| | | | |
|---|---|---|---|
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Site Number** 135

**Polygon** A **UTM Coordinate** 17 646625E 4911329N **Vegetation Type** Mixed Cultural Meadow **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACESASA | Tree | Acer saccharum ssp. saccharum | Sugar Maple |
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ARESERP | Herb | Arenaria serpyllifolia | Thyme-leaf Sandwort |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHEALAL | Herb | Chenopodium album var. album | Lamb's Quarters |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CRETECT | Herb | Crepis tectorum | Narrow-leaved Hawk's Beard |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| ERYHIER | Herb | Erysimum hieraciifolium | Hawkweed-leaved Mustard |
| LEPDENS | Herb | Lepidium densiflorum | Common Pepper-grass |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| NEPCATA | Herb | Nepeta cataria | Catnip |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POLCONV | Vine | Polygonum convolvulus | Black Bindweed |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SALDISC | Shrub | Salix discolor | Pussy Willow |
| SALERIO | Shrub | Salix eriocephala | Woolly-headed Willow |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SISALTI | Herb | Sisymbrium altissimum | Tall Tumble-mustard |

| | | | |
|---|---|---|---|
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| THLARVE | Herb | Thlaspi arvense | Field Penny-cress |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

| Polygon | B | UTM Coordinate | 17 646643E 4911272N | Vegetation Type | Awnless Brome Cultural Meadow | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ARESERP | Herb | Arenaria serpyllifolia | Thyme-leaf Sandwort |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CRETECT | Herb | Crepis tectorum | Narrow-leaved Hawk's Beard |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| LEPDENS | Herb | Lepidium densiflorum | Common Pepper-grass |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| NEPCATA | Herb | Nepeta cataria | Catnip |
| PHYHETE | Herb | Physalis heterophylla | Clammy Ground-cherry |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

| Polygon | C | UTM Coordinate | 17 646679E 4911348N | Vegetation Type | Mixed Cultural Meadow | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACHMIMI | Herb | Achillea millefolium ssp. millefolium | Common Yarrow |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ARESERP | Herb | Arenaria serpyllifolia | Thyme-leaf Sandwort |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CRETECT | Herb | Crepis tectorum | Narrow-leaved Hawk's Beard |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ELYREPE | Graminoid | Elymus repens | Quack Grass |
| FRAVIRG | Herb | Fragaria virginiana | Scarlet Strawberry |
| LEPDENS | Herb | Lepidium densiflorum | Common Pepper-grass |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SILANTI | Herb | Silene antirrhina | Sleepy Catchfly |
| SOLCANA | Herb | Solidago canadensis | Canada Goldenrod |
| SOLCANA | Herb | Solidago canadensis var. canadensis | Canada Goldenrod |
| TRADUBI | Herb | Tragopogon dubius | Doubtful Goat's-beard |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Site Number** 137

| Polygon | A | UTM Coordinate | 0687561E 488278N | Vegetation Type | Dry-Moist Cultural Old Field Meadow Type | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|

| | | | |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ARCMIMI | Herb | Arctium minus ssp. minus | Common Burdock |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| COR__SP | Herb | Corallorhiza sp | Coralroot Species |
| CORVARI | Herb | Coronilla varia | Trailing Crown-vetch |
| CYNROSS | Vine | Cynanchum rossicum | White Swallow-wort |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| DIGSANG | Graminoid | Digitaria sanguinalis | Large Crabgrass |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |
| FESARUN | Graminoid | Festuca arundinacea | Tall Fescue |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| RUDHIRT | Herb | Rudbeckia hirta | Black-eyed Susan |
| SILLATI | Herb | Silene latifolia | Bladder Campion |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Site Number** 139

| Polygon | A | UTM Coordinate | 17 688010E 4881979N | Vegetation Type | Dry-moist cultural old field meadow | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| ASTLALA | Herb | Symphyotrichum lateriflorum var. lateriflorum? (As | Small White Aster (One-sided Aster) |
| ASTLALA | Herb | Symphyotrichum lanceolatum ssp. (Aster lanceolat | Panicled Aster |
| ASTLALA | Herb | Symphyotrichum laeve var. laeve?(Aster laevis var. l | Smooth Aster |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CAR__SP | Sedge | Carex sp | Sedge Species |
| CENMACU | Herb | Centaurea maculosa | Spotted Knapweed |
| CIRARVE | Herb | Cirsium arvense | Canada Thistle |
| CORVARI | Herb | Coronilla varia | Trailing Crown-vetch |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| EUTGRAM | Herb | Euthamia graminifolia | Grass-leaved Goldenrod |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| FRAAMER | Tree | Fraxinus americana | White Ash |
| FRAVIVI | Herb | Fragaria virginiana ssp. virginiana | Common Strawberry |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MALPUMI | Shrub | Malus pumila | Common Apple |
| MATPERF | Herb | Matricaria perforata | Scentless Chamomile |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |

| | | | |
|---|---|---|---|
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| RHUTYPH | Shrub | Rhus typhina | Staghorn Sumac |
| ROBPSEU | Tree | Robinia pseudo-acacia | Black Locust |
| ROSMULT | Shrub | Rosa multiflora | Multiflora Rose |
| RUDHIRT | Herb | Rudbeckia hirta | Black-eyed Susan |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SAL__SP | Shrub | Salix sp | Willow Species |
| SALERIO | Shrub | Salix eriocephala | Woolly-headed Willow |
| SAPOFFI | Herb | Saponaria officinalis | Bouncing Bet |
| SILLATI | Herb | Silene latifolia | Bladder Campion |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRAPRPR | Herb | Tragopogon pratensis ssp. pratensis | Meadow Goat's-beard |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| TUSFARF | Herb | Tussilago farfara | Coltsfoot |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |
| VITRIPA | Woody Vine | Vitis riparia | Riverbank Grape |

**Site Number** 140

**Polygon** A **UTM Coordinate** 0685998E 4882847N **Vegetation Type** DRY MOIST CULTURAL OLD FIELD MEADOW **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| BARVULG | Herb | Barbarea vulgaris | Yellow Rocket (Common Wintercress) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CONCANA | Herb | Conyza canadensis | Horseweed |
| DACGLOM | Graminoid | Dactylis glomerata | Orchard Grass |

| | | | |
|---|---|---|---|
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| HIEXFLO | Herb | Hieracium X floribundum | King Devil Hawkweed |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LACSERR | Herb | Lactuca serriola | Prickly Lettuce |
| LOLPERE | Graminoid | Lolium perenne | Perennial Rye Grass |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDLUPU | Herb | Medicago lupulina | Black Medick |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POAPRPR | Graminoid | Poa pratensis ssp. pratensis | Kentucky Blue Grass |
| SILLATI | Herb | Silene latifolia | Bladder Campion |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |

**Polygon** B **UTM Coordinate** 0687040E 4882090N **Vegetation Type** Dry-Moist Cultural Old Field Meadow Type **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AMBARTE | Herb | Ambrosia artemisiifolia | Annual Ragweed (Common Ragweed) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| BARVULG | Herb | Barbarea vulgaris | Yellow Rocket (Common Wintercress) |
| BROININ | Graminoid | Bromus inermis ssp. inermis | Awnless Brome (Smooth Brome) |
| CENMACU | Herb | Centaurea maculosa | Spotted Knapweed |
| CHRLEUC | Herb | Chrysanthemum leucanthemum | Ox-eye Daisy |
| CYNROSS | Vine | Cynanchum rossicum | White Swallow-wort |
| DAUCARO | Herb | Daucus carota | Wild Carrot |

| | | | |
|---|---|---|---|
| DESCANA | Herb | Desmodium canadense | Showy Tick-trefoil |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| ERISTRI | Herb | Erigeron strigosus | Lesser Daisy Fleabane |
| FESRUBR | Graminoid | Festuca rubra | Red Fescue |
| HYPPERF | Herb | Hypericum perforatum | Common St. John's-wort |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |
| MEDSASA | Herb | Medicago sativa ssp. sativa | Alfalfa |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MONFIST | Herb | Monarda fistulosa | Wild Bergamot |
| OENPARV | Herb | Oenothera parviflora | Small-flowered Evening-primrose |
| PHAARUN | Graminoid | Phalaris arundinacea | Reed Canary Grass |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| PINSYLV | Tree | Pinus sylvestris | Scots Pine |
| POACOMP | Graminoid | Poa compressa | Canada Blue Grass |
| POPTREM | Tree | Populus tremuloides | Trembling Aspen |
| POTRECT | Herb | Potentilla recta | Rough-fruited Cinquefoil |
| RUMCRIS | Herb | Rumex crispus | Curly Dock |
| SALERIO | Shrub | Salix eriocephala | Woolly-headed Willow |
| SAPOFFI | Herb | Saponaria officinalis | Bouncing Bet |
| SILLATI | Herb | Silene latifolia | Bladder Campion |
| SOLALAL | Herb | Solidago altissima var. altissima | Tall Goldenrod |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |

**Site Number** 141

**Polygon** A **UTM Coordinate** 18 355440E 4912774N **Vegetation Type** Dry-Moist Old Field Meadow Type **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| LOTCORN | Herb | Lotus corniculatus | Bird's-foot Trefoil |

| | | | |
|---|---|---|---|
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PHRAUST | Graminoid | Phragmites australis | Common Reed |
| PLAMAJO | Herb | Plantago major | Common Plantain |
| POPBABA | Tree | Populus balsamifera ssp. balsamifera | Balsam Poplar |
| SOL__SP | Herb | Solidago sp | Goldenrod Species |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

**Site Number** 144

**Polygon** A **UTM Coordinate** 18 375407E, 4991273N **Vegetation Type** Dry-Moist Old Field Meadow Type **Vegetation Type Code** CUM1-1

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGR__SP | Herb | Agrimonia sp | Agrimony Species |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| CICINTY | Herb | Cichorium intybus | Chicory |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| ECHVULG | Herb | Echium vulgare | Viper's Bugloss |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MONFIST | Herb | Monarda fistulosa | Wild Bergamot |
| PINRESI | Tree | Pinus resinosa | Red Pine |
| POA__SP | Graminoid | Poa sp | Blue Grass Species |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| SILVULG | Herb | Silene vulgaris | Catchfly |
| SOL__SP | Herb | Solidago sp | Goldenrod Species |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| UTRVULG | Herb | Utricularia vulgaris | Common Bladderwort |
| VERTHAP | Herb | Verbascum thapsus | Common Mullein |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

| Polygon | B | UTM Coordinate | 18 375790E, 4991495N | Vegetation Type | Dry-Moist Old Field Meadow Type | Vegetation Type Code | CUM1-1 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| AGRGIGA | Graminoid | Agrostis gigantea | Black Bentgrass (Redtop Grass) |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| FRAVIVI | Herb | Fragaria virginiana ssp. virginiana | Common Strawberry |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| PHLPRAT | Graminoid | Phleum pratense | Timothy |
| POA__SP | Graminoid | Poa sp | Blue Grass Species |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| RUDHIRT | Herb | Rudbeckia hirta | Black-eyed Susan |
| SOL__SP | Herb | Solidago sp | Goldenrod Species |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

| Site Number | 146 |
|---|---|

| Polygon | A | UTM Coordinate | 18 4033018E, 4919228N | Vegetation Type | White Pine Coniferous Plantation Type | Vegetation Type Code | CUP3-2 |
|---|---|---|---|---|---|---|---|

| Species Code | TYPE | SCIENTIFIC NAME | COMMON NAME |
|---|---|---|---|
| ACENEGU | Tree | Acer negundo | Manitoba Maple |
| ASCSYRI | Herb | Asclepias syriaca | Kansas Milkweed (Common Milkweed) |
| DAUCARO | Herb | Daucus carota | Wild Carrot |
| MELALBA | Herb | Melilotus alba | White Sweet-clover |
| MONHYPO | Herb | Monotropa hypopithys | Pinesap |
| PINSTRO | Tree | Pinus strobus | Eastern White Pine |
| RUBIDID | Shrub | Rubus idaeus ssp. idaeus | Red Raspberry |
| SOL__SP | Herb | Solidago sp | Goldenrod Species |
| TAROFFI | Herb | Taraxacum officinale | Common Dandelion |
| TRIPRAT | Herb | Trifolium pratense | Red Clover |
| VICCRAC | Vine | Vicia cracca | Cow Vetch |

# Appendix C

## List of Vegetation Communities by Individual Site

# Task 1 Community Classification

**Site Number** 101

**Polygon** A **UTM Coordinates** 17 363350E 4661303N

| | | ELC Code |
|---|---|---|
| Community Class: | | |
| Community Series | | |
| Eco Site | | |
| Vegetation Site | Mixed Cultural Meadow | CUM1-1 |

**Polygon** B **UTM Coordinates** 17 363338E 4661193N

| | | ELC Code |
|---|---|---|
| Community Class: | | |
| Community Series | | |
| Eco Site | | |
| Vegetation Site | Mixed Cultural Meadow | CUM1-1 |

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**Site Number** 103

**Polygon** A **UTM Coordinates** 17 439800E 4765800N

| | | ELC Code |
|---|---|---|
| Community Class: | | |
| Community Series | | |
| Eco Site | | |
| Vegetation Site | Mixed Cultural meadow | CUM1-1 |

**Polygon** B **UTM Coordinates** 17 439800E 4765800N

| | | ELC Code |
|---|---|---|
| Community Class: | | |
| Community Series | | |
| Eco Site | | |
| Vegetation Site | Mixed Cultural Meadow | CUM1-1 |

---

**Site Number** 110

**Polygon** A **UTM Coordinates** 17 499119E 4795088N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | Cultural | CU |
| **Community Series** | Cultural Meadow | CUM |
| **Eco Site** | Mineral Cultural Meadow Ecosite | CUM1 |
| **Vegetation Site** | Dry-Moist Old Field Meadow Type | CUM1-1 |

**Polygon** B **UTM Coordinates** 17 499051E 4795477N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | Cultural | CU |
| **Community Series** | Cultural Meadow | CUM |
| **Eco Site** | Mineral Cultural Meadow Ecosite | CUM1 |
| **Vegetation Site** | Dry-Moist Old Field Meadow Type | CUM1-1 |

**Polygon** C **UTM Coordinates** 17 499160E 4795658N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | Marsh | MA |
| **Community Series** | Meadow Marsh | MAM |
| **Eco Site** | Mineral Meadow Marsh Ecosite | MAM2 |
| **Vegetation Site** | Reed- canary Grass Mineral Meado | MAM2-2 |

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**Site Number** 111

**Polygon** A **UTM Coordinates** 17 510829E 4934795N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | Cultural | CU |
| **Community Series** | Cultural Meadow | CUM |
| **Eco Site** | Mineral Cultural Meadow Ecosite | CUM1 |
| **Vegetation Site** | Dry-Moist Old Field Meadow Type | CUM1-1 |

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**Site Number** 115

**Polygon** A **UTM Coordinates** 17 595070E 4862672N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | Forest | FO |
| **Community Series** | Deciduous Forest | FOD |
| **Eco Site** | Fresh- Moist Lowland Deciduous Fo | FOD7 |
| **Vegetation Site** | Fresh-Moist Willow Lowland Decidu | FOD7-3 |

| Polygon | B | UTM Coordinates | 17 595128E 4862510N |
|---|---|---|---|

| | | ELC Code |
|---|---|---|
| Community Class: | Cultural | CU |
| Community Series | Cultural Meadow | CUM |
| Eco Site | Mineral Cultural Meadow Ecosite | CUM1 |
| Vegetation Site | Dry-Moist Old Field Meadow Type | CUM1-1 |

| Polygon | C | UTM Coordinates | 17 595002E 4862490N |
|---|---|---|---|

| | | ELC Code |
|---|---|---|
| Community Class: | Cultural | CU |
| Community Series | Cultural Woodland | CUW |
| Eco Site | Mineral Cultural Woodland Ecosite | CUW1 |
| Vegetation Site | NA | CUM1-1 |

| Polygon | D | UTM Coordinates | 17 595229E 4862753N |
|---|---|---|---|

| | | ELC Code |
|---|---|---|
| Community Class: | Cultural | CU |
| Community Series | Cultural Meadow | CUM |
| Eco Site | Mineral Cultural Meadow Ecosite | CUM1 |
| Vegetation Site | Dry-Moist Old Field Meadow Type | CUM1-1 |

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**Site Number** **116**

| Polygon | A | UTM Coordinates | 17 578989E 4856375N |
|---|---|---|---|

| | | ELC Code |
|---|---|---|
| Community Class: | | |
| Community Series | | |
| Eco Site | | |
| Vegetation Site | Mixed Old Field Meadow | CUM1-1 |

| Polygon | B | UTM Coordinates | 17 578907E 4856291N |
|---|---|---|---|

| | | ELC Code |
|---|---|---|
| Community Class: | | |
| Community Series | | |
| Eco Site | | |
| Vegetation Site | Forb Cultural Meadow | CUM1-1 |

| Polygon | C | UTM Coordinates | 17 578599E 4855765N |
|---|---|---|---|

**ELC Code**

**Community Class:**

**Community Series**

**Eco Site**

**Vegetation Site** Mixed Old Field Cultural Meadow CUM1-1

**Polygon** D **UTM Coordinates** 17 578754E 4855803N

**ELC Code**

**Community Class:**

**Community Series**

**Eco Site**

**Vegetation Site** Mixed Cultural Meadow CUM1-1

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**Site Number** **120**

**Polygon** A **UTM Coordinates** 17 580180E 4830375N

**ELC Code**

**Community Class:**

**Community Series**

**Eco Site**

**Vegetation Site** Mixed Cultural Meadow CUM1-1

**Polygon** B **UTM Coordinates** 17 580127E 4830346N

**ELC Code**

**Community Class:**

**Community Series**

**Eco Site**

**Vegetation Site** Mixed Cultural Meadow CUM1-1

**Polygon** C **UTM Coordinates** 17 580128E 4830663N

**ELC Code**

**Community Class:**

**Community Series**

**Eco Site**

**Vegetation Site** Red Pine Plantation CUP3-1

**Polygon** D **UTM Coordinates** 17 580909E 4830515N

ELC Code

Community Class:

Community Series

Eco Site

Vegetation Site Mixed Cultural Meadow CUM1-1

Polygon E UTM Coordinates 17 580837E 4830784N

ELC Code

Community Class:

Community Series

Eco Site

Vegetation Site White Spruce Plantation CUP

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Site Number **121**

Polygon A UTM Coordinates 17 583829E 4819776N

ELC Code

Community Class:

Community Series

Eco Site

Vegetation Site Sumac Cultural Thicket CUT1-1 CUT1-1

Polygon B UTM Coordinates 17 583902E 4819738N

ELC Code

Community Class:

Community Series

Eco Site

Vegetation Site Green Ash - Black Locust Cultural Th CUT

Polygon C UTM Coordinates 17 583934E 4819696N

ELC Code

Community Class:

Community Series

Eco Site

Vegetation Site Mixed Cultural Thicket CUT

Polygon D UTM Coordinates 17 584022E 4819596N

| | | | |
|---|---|---|---|
| | | | **ELC Code** |
| **Community Class:** | | | |
| **Community Series** | | | |
| **Eco Site** | | | |
| **Vegetation Site** | Old Field Cultural Meadow | | CUM1-1 |

**Polygon** E **UTM Coordinates** 17 584229E 4819982N

| | | | |
|---|---|---|---|
| | | | **ELC Code** |
| **Community Class:** | | | |
| **Community Series** | | | |
| **Eco Site** | | | |
| **Vegetation Site** | Cultural Thicket | | CUT |

**Polygon** F **UTM Coordinates** 17 584154E 4820049N

| | | | |
|---|---|---|---|
| | | | **ELC Code** |
| **Community Class:** | | | |
| **Community Series** | | | |
| **Eco Site** | | | |
| **Vegetation Site** | Willow-Dogwood Cultural Thicket | | CUT |

**Polygon** G **UTM Coordinates** 17 583923E 4820398N

| | | | |
|---|---|---|---|
| | | | **ELC Code** |
| **Community Class:** | | | |
| **Community Series** | | | |
| **Eco Site** | | | |
| **Vegetation Site** | Fresh Black Locust Deciduous Forest | | FOD |

**Polygon** H **UTM Coordinates** 17 583957E 4820432N

| | | | |
|---|---|---|---|
| | | | **ELC Code** |
| **Community Class:** | | | |
| **Community Series** | | | |
| **Eco Site** | | | |
| **Vegetation Site** | Old Field Cultural Meadow | | CUM1-1 |

**Polygon** I **UTM Coordinates** 17 583474E 4820513N

**ELC Code**

**Community Class:**

**Community Series**

**Eco Site**

**Vegetation Site** Mixed Old Field Cultural Meadow CUM1-1

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**Site Number** **123**

**Polygon** A **UTM Coordinates** 17 583088E 4816556N

**ELC Code**

**Community Class:**

**Community Series**

**Eco Site**

**Vegetation Site** Mixed Cultural Meadow CUM1-1

**Polygon** B **UTM Coordinates** 17 583101E 4816593N

**ELC Code**

**Community Class:**

**Community Series**

**Eco Site**

**Vegetation Site** Mixed Cultural Meadow CUM1-1

**Polygon** C **UTM Coordinates** 17 582903E 4816457N

**ELC Code**

**Community Class:**

**Community Series**

**Eco Site**

**Vegetation Site** Weed Meadow CUM1-1

**Polygon** D **UTM Coordinates** 17 583536E 4816727N

**ELC Code**

**Community Class:**

**Community Series**

**Eco Site**

**Vegetation Site** Crown Vetch Cultural Meadow CUM1-1

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**Site Number** **125**

| | | | |
|---|---|---|---|
| **Polygon** A | **UTM Coordinates** | Unknown | |
| | | | **ELC Code** |
| **Community Class:** | | | |
| **Community Series** | | | |
| **Eco Site** | | | |
| **Vegetation Site** | | Dry-Moist Cultural Old Field Meado | CUM1-1 |
| **Polygon** B | **UTM Coordinates** | Unknown | |
| | | | **ELC Code** |
| **Community Class:** | | | |
| **Community Series** | | | |
| **Eco Site** | | | |
| **Vegetation Site** | | Dry-Moist Cultural Old Field Meado | CUM1-1 |
| **Polygon** C | **UTM Coordinates** | Unknown | |
| | | | **ELC Code** |
| **Community Class:** | | | |
| **Community Series** | | | |
| **Eco Site** | | | |
| **Vegetation Site** | | Black Locust - Trembling Aspen Cult | CUW1 |

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**Site Number** 128

| | | | |
|---|---|---|---|
| **Polygon** A | **UTM Coordinates** | | |
| | | | **ELC Code** |
| **Community Class:** | | | |
| **Community Series** | | | |
| **Eco Site** | | | |
| **Vegetation Site** | | | |

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**Site Number** 129

| | | |
|---|---|---|
| **Polygon** A | **UTM Coordinates** | 17 648976E 4878577N |

| | | | |
|---|---|---|---|
| | | | ELC Code |
| Community Class: | | | |
| Community Series | | | |
| Eco Site | | | |
| Vegetation Site | Forb Cultural Meadow | | CUM1-1 |

**Polygon** B **UTM Coordinates** 17 648974E 4878704N

| | | |
|---|---|---|
| | | ELC Code |
| Community Class: | | |
| Community Series | | |
| Eco Site | | |
| Vegetation Site | Mixed Cultural Meadow | CUM1-1 |

**Polygon** C **UTM Coordinates** 17 649132E 4878486N

| | | |
|---|---|---|
| | | ELC Code |
| Community Class: | | |
| Community Series | | |
| Eco Site | | |
| Vegetation Site | Dry Scots Pine Cultural Thicket | CUT |

**Polygon** D **UTM Coordinates** 17 649055E 4878487N

| | | |
|---|---|---|
| | | ELC Code |
| Community Class: | | |
| Community Series | | |
| Eco Site | | |
| Vegetation Site | Scots Pine Coniferous Forest | |

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**Site Number** 130

**Polygon** A **UTM Coordinates** 17 648621E 4877859N

| | | |
|---|---|---|
| | | ELC Code |
| Community Class: | | |
| Community Series | | |
| Eco Site | | |
| Vegetation Site | Forb Cultural Meadow | |

**Polygon** B **UTM Coordinates** 17 648620E 4877800N

| | | | | |
|---|---|---|---|---|
| | | | | ELC Code |
| | | Community Class: | | |
| | | Community Series | | |
| | | Eco Site | | |
| | | Vegetation Site | Forb Cultural Meadow | CUM1-1 |
| Polygon | C | UTM Coordinates | 17 648629E 4877707N | |
| | | | | ELC Code |
| | | Community Class: | | |
| | | Community Series | | |
| | | Eco Site | | |
| | | Vegetation Site | Forb Cultural Meadow | CUM1-1 |
| Polygon | D | UTM Coordinates | 17 648544E 4877647N | |
| | | | | ELC Code |
| | | Community Class: | | |
| | | Community Series | | |
| | | Eco Site | | |
| | | Vegetation Site | forb cultural meadow with planted | CUM1-1 |

---

| | | | | | |
|---|---|---|---|---|---|
| Site Number | 131 | | | | |
| | Polygon | A | UTM Coordinates | 17 643578E 4878610N | |
| | | | | | ELC Code |
| | | | Community Class: | | |
| | | | Community Series | | |
| | | | Eco Site | | |
| | | | Vegetation Site | Mixed Cultural Meadow | CUM1-1 |
| | Polygon | B | UTM Coordinates | 17 643645E 4878627N | |
| | | | | | ELC Code |
| | | | Community Class: | | |
| | | | Community Series | | |
| | | | Eco Site | | |
| | | | Vegetation Site | (Pioneer) Mixed Cultural Meadow | CUM1-1 |
| | Polygon | C | UTM Coordinates | 17 643785E 4878631N | |

| | | | |
|---|---|---|---|
| | | | **ELC Code** |
| | **Community Class:** | | |
| | **Community Series** | | |
| | **Eco Site** | | |
| | **Vegetation Site** | Mixed Cultural Meadow | CUM1-1 |

---

**Site Number** **132**

**Polygon** A **UTM Coordinates** 17 644945E 4880450N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | | |
| **Community Series** | | |
| **Eco Site** | | |
| **Vegetation Site** | Mixed Cultural Meadow | CUM1-1 |

**Polygon** B **UTM Coordinates** 17644800E 4880410N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | | |
| **Community Series** | | |
| **Eco Site** | | |
| **Vegetation Site** | Mixed Meadow with Scots Pine esta | CUM1-1 |

---

**Site Number** **133**

**Polygon** A **UTM Coordinates** 17 630810E 4898340N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | | |
| **Community Series** | | |
| **Eco Site** | | |
| **Vegetation Site** | Forb Cultural Meadow | CUM1-1 |

**Polygon** B **UTM Coordinates** 17 630810E 4898340N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | | |
| **Community Series** | | |
| **Eco Site** | | |
| **Vegetation Site** | Forb Cultural Meadow | CUM1-1 |

| | | | |
|---|---|---|---|
| **Polygon** | D | **UTM Coordinates** | 17 630810E 4898340N |
| | | | **ELC Code** |
| | **Community Class:** | | |
| | **Community Series** | | |
| | **Eco Site** | | |
| | **Vegetation Site** | Scots Pine Plantation | CUP3-3 |

---

**Site Number** **134**

| | | | |
|---|---|---|---|
| **Polygon** | A | **UTM Coordinates** | 17 640301E 4905536N |
| | | | **ELC Code** |
| | **Community Class:** | | |
| | **Community Series** | | |
| | **Eco Site** | | |
| | **Vegetation Site** | Mixed Cultural Meadow | CUM1-1 |
| **Polygon** | B | **UTM Coordinates** | 17 640390E 4905570N |
| | | | **ELC Code** |
| | **Community Class:** | | |
| | **Community Series** | | |
| | **Eco Site** | | |
| | **Vegetation Site** | Goldenrod Cultural Meadow | CUM1-1 |

---

**Site Number** **135**

| | | | |
|---|---|---|---|
| **Polygon** | A | **UTM Coordinates** | 17 646625E 4911329N |
| | | | **ELC Code** |
| | **Community Class:** | | |
| | **Community Series** | | |
| | **Eco Site** | | |
| | **Vegetation Site** | Mixed Cultural Meadow | CUM1-1 |
| **Polygon** | B | **UTM Coordinates** | 17 646643E 4911272N |

ELC Code

Community Class:

Community Series

Eco Site

Vegetation Site | Awnless Brome Cultural Meadow | CUM1-1

Polygon C | UTM Coordinates 17 646679E 4911348N

ELC Code

Community Class:

Community Series

Eco Site

Vegetation Site | Mixed Cultural Meadow | CUM1-1

---

Site Number 137

Polygon A | UTM Coordinates 0687561E 488278N

ELC Code

Community Class:

Community Series

Eco Site

Vegetation Site | Dry-Moist Cultural Old Field Meado | CUM1-1

---

Site Number 139

Polygon A | UTM Coordinates 17 688010E 4881979N

ELC Code

Community Class:

Community Series

Eco Site

Vegetation Site | Dry-moist cultural old field meadow | CUM1-1

---

Site Number 140

Polygon A | UTM Coordinates 0685998E 4882847N

| | | | |
|---|---|---|---|
| | | | **ELC Code** |
| **Community Class:** | | | |
| **Community Series** | | | |
| **Eco Site** | | | |
| **Vegetation Site** | DRY MOIST CULTURAL OLD FIELD M | | CUM1-1 |

**Polygon** B **UTM Coordinates** 0687040E 4882090N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | | |
| **Community Series** | | |
| **Eco Site** | | |
| **Vegetation Site** | Dry-Moist Cultural Old Field Meado | CUM1-1 |

---

**Site Number** 141

**Polygon** A **UTM Coordinates** 18 355440E 4912774N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | Cultural | CU |
| **Community Series** | Cultural Meadow | CUM |
| **Eco Site** | Mineral Cultural Meadow Ecosite | CUM1 |
| **Vegetation Site** | Dry-Moist Old Field Meadow Type | CUM1-1 |

---

**Site Number** 144

**Polygon** A **UTM Coordinates** 18 375407E, 4991273N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | Cultural | CU |
| **Community Series** | Cultural Meadow | CUM |
| **Eco Site** | Mineral Cultural Meadow Ecosite | CUM1 |
| **Vegetation Site** | Dry-Moist Old Field Meadow Type | CUM1-1 |

**Polygon** B **UTM Coordinates** 18 375790E, 4991495N

| | | |
|---|---|---|
| | | **ELC Code** |
| **Community Class:** | Cultural | CU |
| **Community Series** | Cultural Meadow | CUM |
| **Eco Site** | Mineral Cultural Meadow Ecosite | CUM1 |
| **Vegetation Site** | Dry-Moist Old Field Meadow Type | CUM1-1 |

| | | | |
|---|---|---|---|
| **Site Number** | **146** | | |
| **Polygon** | **A** | **UTM Coordinates** | 18 4033018E, 4919228N |

| | | ELC Code |
|---|---|---|
| **Community Class:** | Cultural | CU |
| **Community Series** | Plantation | CUP |
| **Eco Site** | Coniferous Plantation | CUP3 |
| **Vegetation Site** | White Pine Coniferous Plantation Ty | CUP3-2 |

# CHAPTER 5

# SAROS PAPER 6 REHABILITATION

# TASK 2 – REVIEW OF SURRENDERED LICENCES

---

## TABLE OF CONTENTS

Page

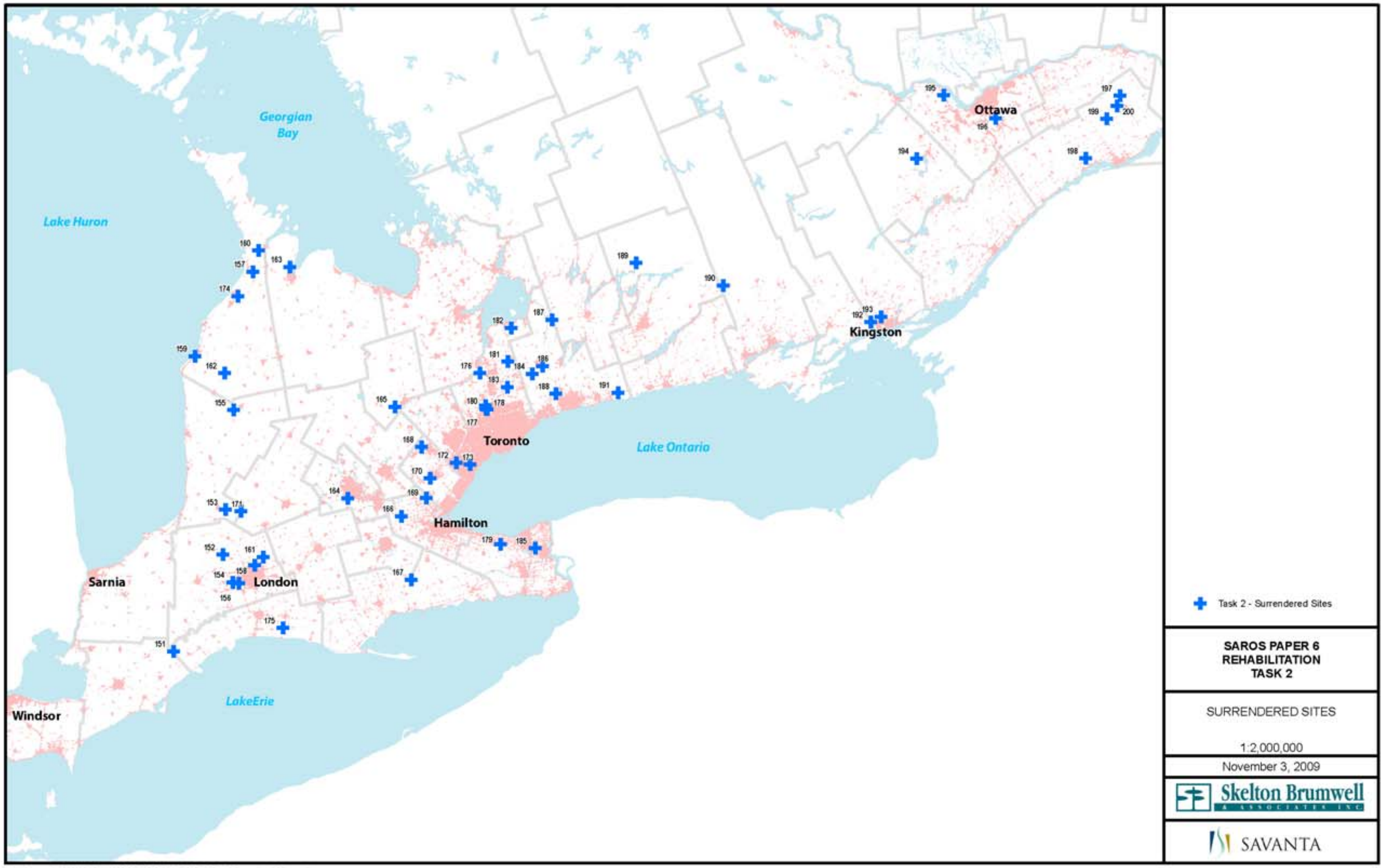
# 1.0 INTRODUCTION

The objective of Task 2 was to "*review a list of 50 surrendered licences provided by MNR that have been rehabilitated and list range of after uses*".

A licence may be surrendered by the licensee once MNR is satisfied that all fees have been paid and that all activities specified by the Site Plan as required for final rehabilitation have been completed (ARA, Section 19). At minimum the activities for rehabilitation usually involve the grading of slopes and the pit/quarry floor, replacement of overburden and topsoil, establishing vegetation to control erosion and removal of equipment (MNR, Provincial Standards).

For this task MNR initially provided a list of the 50 licences most recently surrendered which included 33 pits and 17 quarries. Ten of these, including 7 pits and 3 quarries, were found to have been amalgamated with other licences still in operation, or the files could not be located. They were replaced with the next sites surrendered in reverse chronological order resulting in a total of 37 pits and 13 quarries. The pit licences included in the study were surrendered between December 1, 2005 and June 3, 2009. The quarry licences included were surrendered between May 15, 1998 and April 1, 2008. Figure 1 illustrates the geographic location of the 50 sites.

## Figure 1 - Surrendered Licence Site Locations



## 2.0 DATA COLLECTION METHODOLOGY

For each of the 50 surrendered licences the following steps were completed using customized data collection forms to record the information.

### 2.1 Background Information

Background information on the sites was obtained from a number of sources. The list of sites provided by MNR included the licence number, licensee's name, site location, size of the licence and maximum tonnage. MNR also provided access to its files for each of the sites which generally included the site plan, licence, and in some cases, other relevant correspondence. These files were reviewed to determine the proposed final end use of the area to be extracted.

**Figure 2 –Photograph of Site Survey –General Forms**


For each site the area to be extracted was obtained from the site plan. This is the area of the licence less the setbacks from roads and adjacent properties, and other areas that are to be left undisturbed. The area to be extracted usually represents the area of the site to be rehabilitated. The site plans were also reviewed to determine the proposed end use after rehabilitation, and whether the rehabilitation of the sites was to include integration with adjacent roads or road allowances, or adjacent pits.

Other references were reviewed to determine if the sites were located within the Greenbelt, the Oak Ridges Moraine or Niagara Escarpment as defined by the relevant Act. Aerial photographs and Teranet property fabric information were obtained from VuMap, a subscription service of First Base Solutions Inc. Other aerial photographs were obtained from Google Maps, and government sources.

## 2.2 Site Visits

Aerial photos were used to make an initial determination of the visibility from public roads. Thirty-nine sites were visited by Skelton, Brumwell or Savanta staff between July 8 and August 11, 2009. Information was collected for each site regarding the extent and category of existing land use and the extent to which the sites were integrated or “fit” into the surrounding land uses and landscapes. Photographs were taken of each site where possible.

**Figure 3 – Photograph of Site 171 - Rehabilitated Pit**

Field visits were not completed for the remaining 11 sites because they were not visible from public roads and/or permission for access was not available.

## 2.3 Creation of the Database

All the data collected, including site photos, was entered into the study database to facilitate analysis for this study. The database may be used going forward by MNR to continue to capture information at the time of licence surrender and facilitate analysis in this regard.

A Site Summary including photographs was prepared for each site. The summaries are included in Appendix A.

# 3.0 ANALYSIS

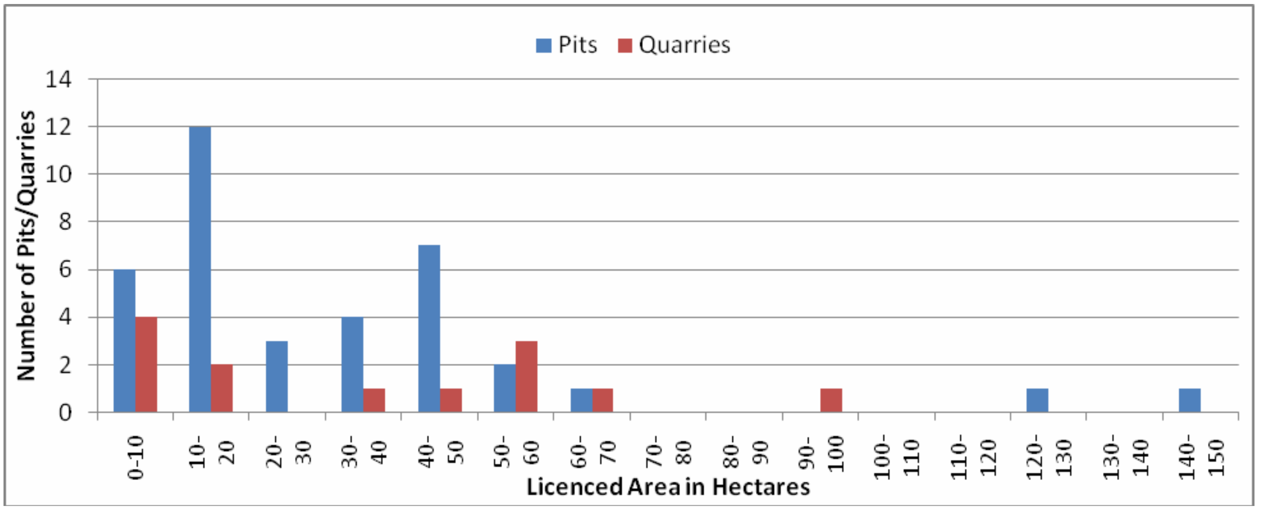
## 3.1 Characterization of Study Sites

The study sites were characterized based on the size of the licenced area, the geographic location, the nature of the surrounding land uses and the proposed final end use.

### 3.1.1 Licenced Area

The licenced areas of the 50 study sites range from 1.5 hectares to 147.8 hectares with an average area of 32.6 hectares. Almost one half, 24 sites, are 20 hectares or less and a further 23 sites are between 20 and 70 hectares. The total licenced area of the surrendered sites is 1629.5 hectares including 1184.8 hectares of former pits and 444.7 hectares of former quarries.

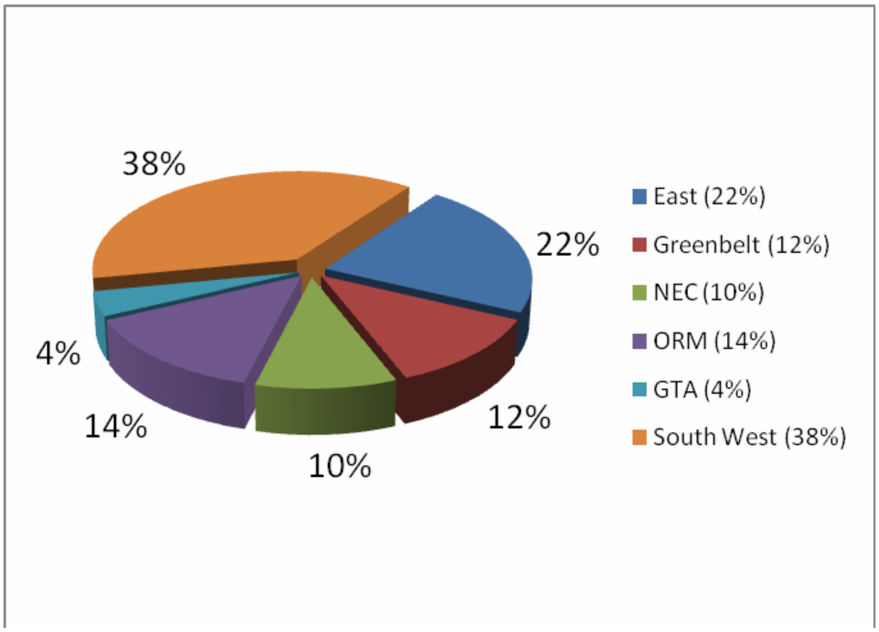
**Figure 4 – Number of Sites by Licenced Area**



### 3.1.2 Geographic Location

The location of each site was identified as East, South West, Oak Ridges Moraine, Niagara Escarpment or Greenbelt areas. Although sites were not specifically chosen in these areas, it maintains consistency with Task 1. The 50 sites for Task 2 included 2 sites in the City of Mississauga which we have called Greater Toronto Area (GTA). The distribution of the sites in these geographic areas is illustrated by Figure 5. It shows 38% in the West, 22% in the East and 40% in the other areas.

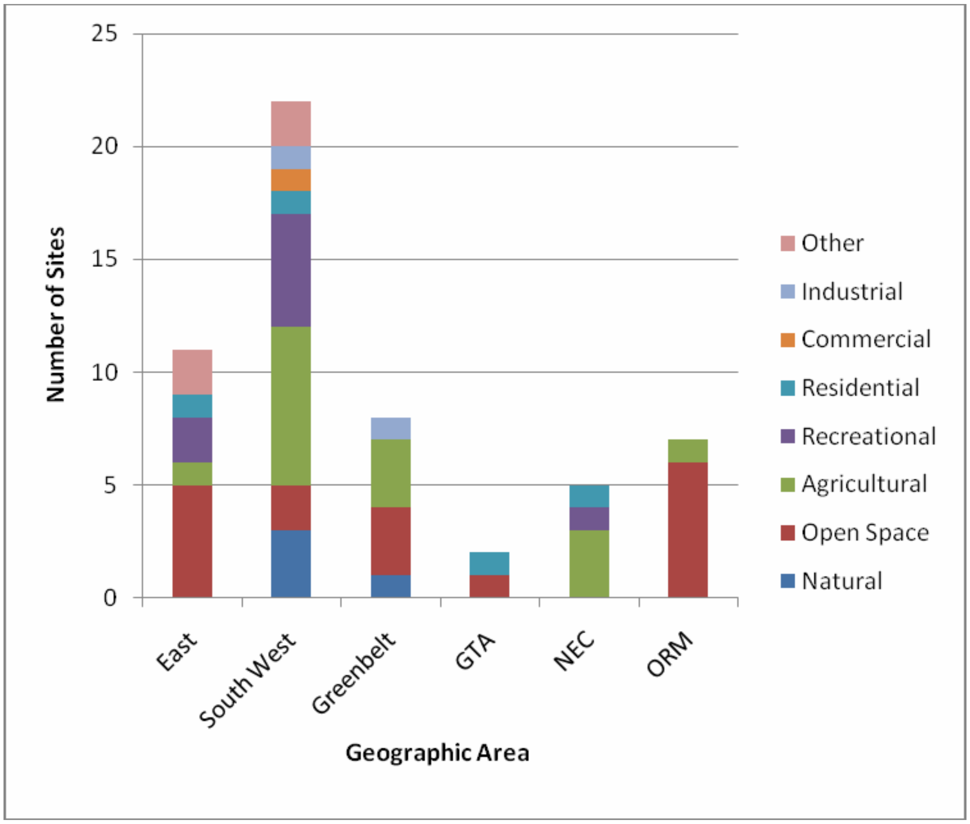
**Figures 5 – Geographic Area**



### 3.1.3 Surrounding Land Use

The land use surrounding the sites is characterized as Urban, Rural or Remote to provide an indication of the distribution of sites in these generalized land use areas. An Urban area has extensive development of residential or industrial/commercial uses, while a Rural area is be primarily agricultural with wooded/natural areas, located along or close to a major road such as a county road or highway. A Remote area is primarily wooded with some agricultural areas, removed from a major road. Thirty-six of the sites are located in Rural areas, 11 in Urban areas and 3 sites in Remote areas. The distribution of the general land use by the geographic areas is shown in Figure 6.

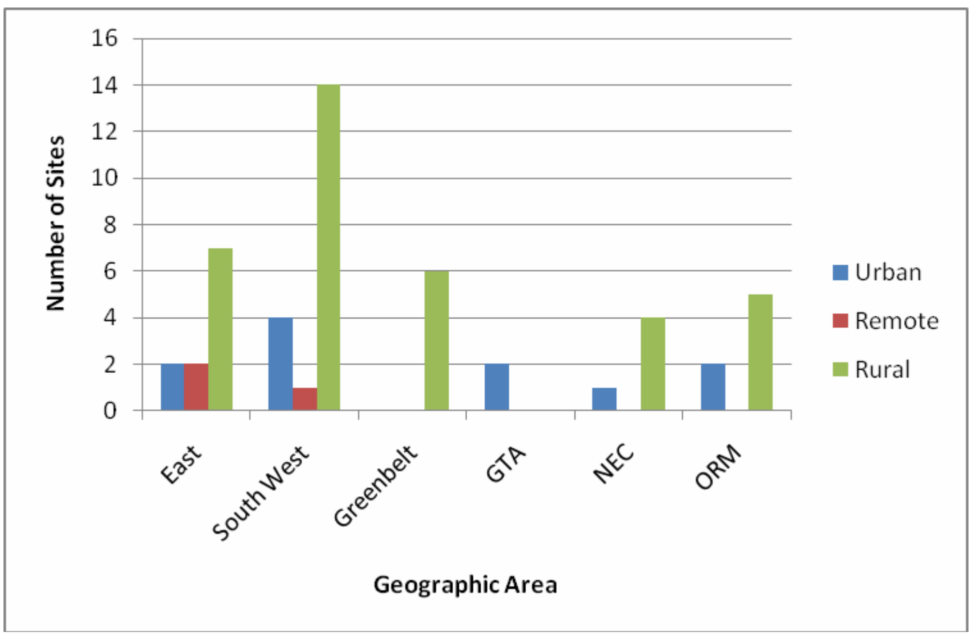
**Figure 6 – General Land Use by Geographic Area**



### 3.1.4 Proposed End Use

Seven general categories of final end uses were noted on the Site Plans reviewed for the subject sites. In most cases the proposed land use was clearly stated. However, there were 6 sites where no land use was specified and only basic rehabilitation including grading, overburden and topsoil replacement, and seeding was required. Three other sites indicated one or more potential final uses subject to additional approvals, but did not specify rehabilitation related to those uses. These 9 sites are included in the "Open Space" category. Three of the Site Plans were illegible. The Rehabilitation Plan was not available for 1 site. These 4 sites are shown in the "Other" category. As illustrated in Figure 7, the proposed uses are well distributed in the geographic areas with typically rural land uses, natural, open space and agricultural, occupying the largest percentage of all areas except the Greater Toronto Area.

**Figure 7 – Proposed Land Use by Geographic Area**



## 3.2 Existing Land Use

### 3.2.1 Land Use Categories

Existing land uses were observed for each of the 50 sites through the site visits and/or review of aerial photography. As some sites have more than one existing land use, including one urban site that has five different categories, each category was assigned a percentage of the rehabilitated area. The categories of existing land use are based on those identified as proposed end uses on the Site Plans. Photographs of examples of each land use are shown in Figures 9 and 10.

Areas described as Natural include those where native materials were used in rehabilitation, or natural regeneration has taken place. The Open Space category was assigned where basic rehabilitation had taken place and where there was no obvious sign of other land uses. In some instances, this may represent an interim land use until approvals are obtained for further development. The Institutional category was added to recognize a school located on a site in Mississauga and Government buildings on a site in Ottawa.

In urban areas, land uses were assigned based on planned development even where the sites were not necessarily fully built for those uses. For instance, one or two sites were identified as residential subdivisions either through correspondence or documents from MNR, signage on the property or from Teranet lot fabric patterns, though no houses had been constructed.

Within some of the land use categories there were sub-categories or specific land uses. For instance, in the three sites in the commercial land use category each have specific subcategories of commercial use (i.e. landscape supplies, grocery/big box retail, gas station/restaurant/hotel). Figure 8 shows the number of sites in each category and sub-category.

**Figure 8 - Table 1 Number of Sites in Land Use Categories and Sub-Categories**

| Category | Sub-Categories | | | |
|---|---|---|---|---|
| **Natural – 9** | Pond – 1 | Woodland - 2 | | |
| **Open Space - 25** | Ponds - 8 | Stormwater Management - 2 | Restored Watercourse - 1 | |
| **Agricultural - 17** | | | | |
| **Recreation – 5** | Private – 1 | Golf Course - 2 | Conservation Area – 1 (Not yet open for public use) | Sports fields, playgound - 1 |
| **Residential – 6** | Single Family - 5 | Townhouse/ Single - 1 | | |
| **Commercial – 3** | Landscape Supplies – 1 | Grocery/Big Box Retail - 1 | Gas Station, Restaurant, Hotel - 1 | |
| **Industrial – 5** | Business Park - 1 | Municipal Waste Disposal Site - 1 | | |
| **Institutional – 2** | Elementary School – 1 | Government Office - 1 | | |
| **Other - 1** | Fill Permit | | | |

The existing land uses identified on each site are not necessarily the same as the proposed end uses from the Site Plans, and may not represent the use of the site at the time of surrendering the licence. The proposed end uses were often identified 20 or more years ago at the time that the site was licenced. In some areas communities near the pit or quarry have grown substantially during extraction of the pit or quarry, providing opportunities for the sites to be developed for uses not initially anticipated. Just as the extraction operation was an interim land use, the initial rehabilitated land use may have been another interim step between extraction and the land use existing today.

Open Space land uses were noted mostly in Rural areas; however some were also in the Urban area. Urban uses are least prevalent, which correlates to the number of Urban sites versus Rural and Remote sites.

**Figure 9 – Examples of After Uses**

**Figure 10 – Examples of After Uses**

### 3.2.2 Integration with Adjacent Land Uses and Landforms

The site visits and review of aerial photos included documentation of general observations of the integration of the rehabilitated sites with adjacent land uses and landscapes. In 34 sites it was observed that existing land uses were well integrated into the surrounding land uses and landscape. This occurred in rural and urban areas. Another 7 sites introduced a new feature to the landscape, such as a pond in an agricultural area, or golf course in a rural area. The remaining 9 sites were assessed as not integrated with the surrounding landscape primarily because they are still in the process of being developed. In general, the land uses observed on the surrendered sites were compatible with the surrounding area and would not be identified as a former pit or quarry to the general public.

Two adjacent subject sites had been integrated both in operation and in rehabilitation. One site was noted to be integrated through rehabilitation with an adjacent pit above the water table. No integration of sites with roads or road allowances was noted.

### 3.2.3 Calculation of Existing Land Use

Based on the site plans for all 50 sites, the total area to be extracted was 1,175 hectares. Although some sites did not appear to have been extracted to the full extent indicated on the site plan, we have equated the area to be extracted to the rehabilitated area of the surrendered licences for the purposes of these calculations.

The percentage assigned to each existing land use was multiplied by the rehabilitated area to calculate the area of each use for each site. The areas were then totalled to provide the land area for each use for the 50 sites. The result is shown in Figures 11, 12 and 13.

**Figure 11 – Area of Rehabilitation by Existing Land Uses For Pits**

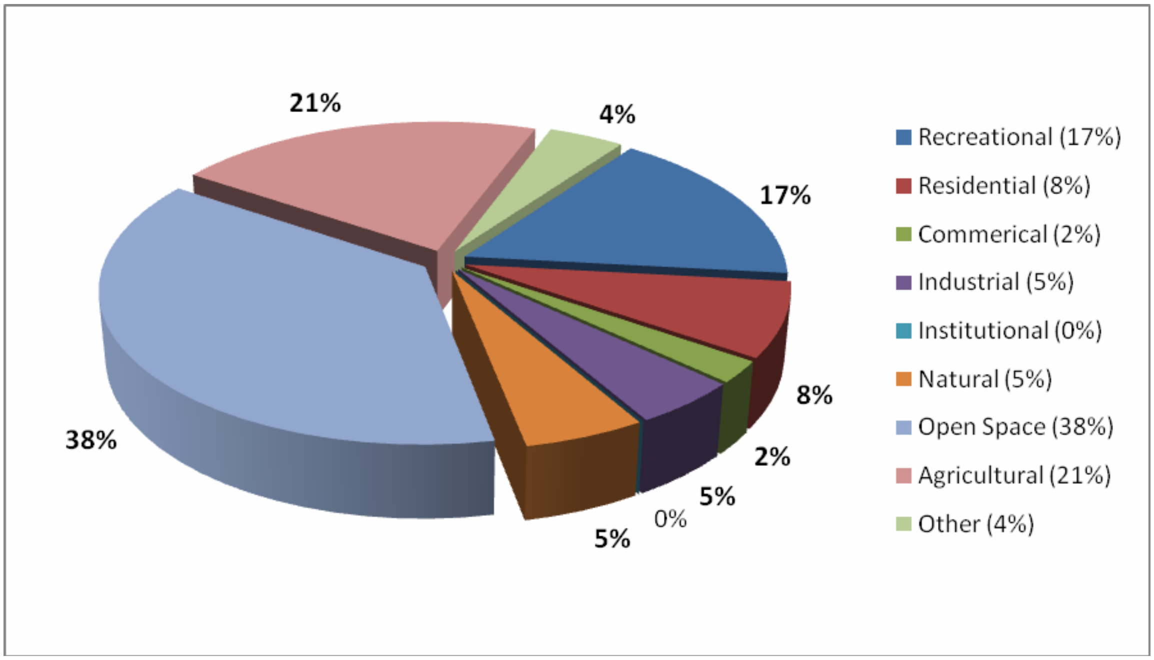



**Figure 12 – Area of Rehabilitation by Existing Land Uses For Quarries**

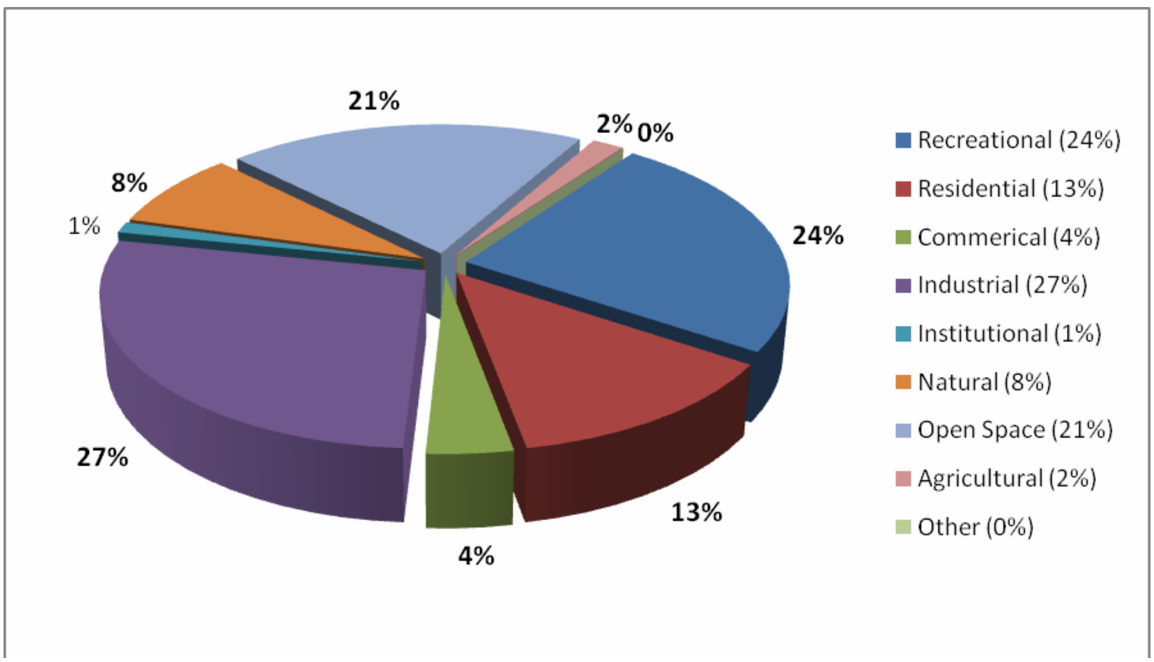
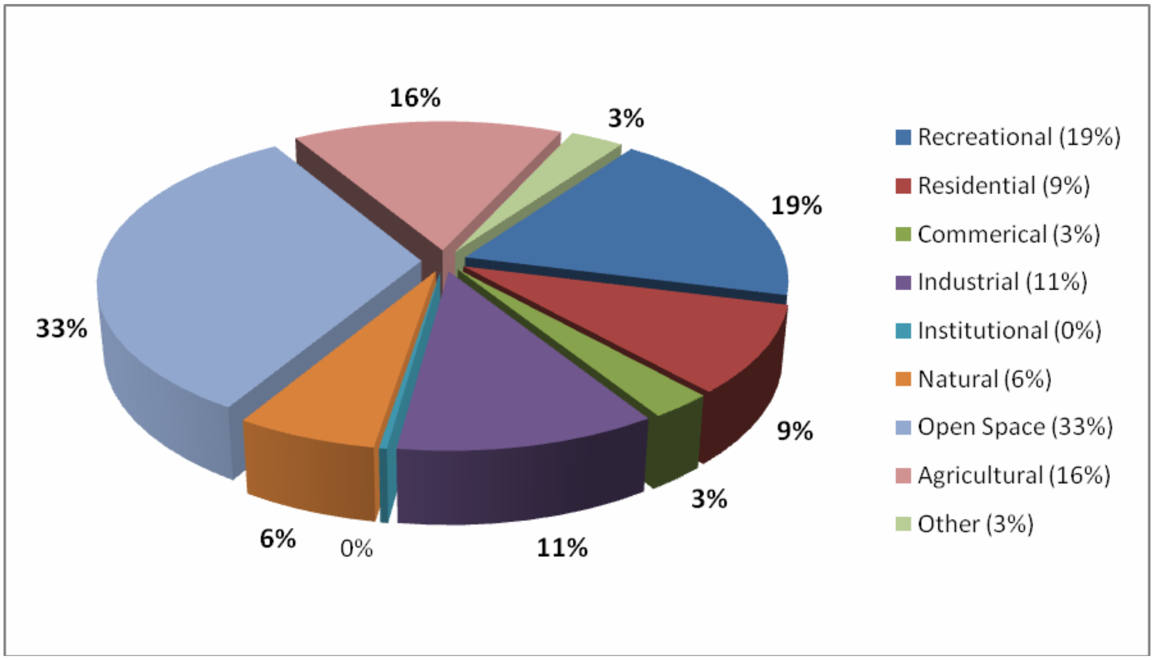


**Figure 13 – Area of Rehabilitation by Existing Land Uses**




## 4.0 CONCLUSIONS AND RECOMMENDATION

The existing, rehabilitated, land uses observed in the 50 subject sites included a wide spectrum of land uses from natural area to municipal landfill site in nine different categories with 20 different sub-categories or specific uses. These sites represent a total of 1,629.5 hectares of land formerly licenced and 1,175 hectares of land rehabilitated from pits and quarries to other uses that are generally well integrated and/or compatible with the surrounding land uses and landscapes.

Most of the sites would not be recognized by the general public as a former licensed pit or quarry and therefore not recognized as rehabilitated lands.

We recommend that prior to licence surrender, MNR complete an information sheet to be entered into the database started by this project. The database can be used to collect data on surrendered licences for the compilation of statistics on after rehabilitated land area and after uses, and to facilitate ongoing research on rehabilitation.

# APPENDIX A

Site Summaries

# Task 2 Appendix A Site Summary

## Site: 151

**Geographical Township:** ALDBOROUGH

**Township or City:** WEST ELGIN M

**County or Region:** ELGIN CO

**Geographical Area:** South West

**Pit or Quarry:** Pit

**Surrender Date:** 07/12/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| Residential | ☐ | Recreational | ☐ | Commercial | ☐ |
| Institutional | ☐ | Industrial | ☐ | Open Space | ☑ |
| Natural | ☐ | Agricultural | ☐ | Other | ☐ |

**Licenced Area:** 14.03

**Area to be Extracted:** 11.18

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| Residential | ☐ | Recreational | ☐ | Commercial | ☐ |
| Institutional | ☐ | Industrial | ☐ | Open Space | ☑ 100% |
| Natural | ☐ | Agricultural | ☐ | Other | ☐ |

Post-extraction lake created. SW shore rehabilitated to lawn, located on a gentle slope, with scattered saplings of red pine planted. Grasses nibbled down by (observed) Canada geese. Steep southern slope at lake edge covered by herbs and willows along waterline. Island in lake with shrubs, trees, of unknown origin.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Good, albeit, abrupt change to forest patch to the south.

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 21/07/2009

**Direction:** SE

**Location:**

**UTM:**

**Description:** General view from Johnston Line

**2203_photo1.JPG**

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 21/07/2009

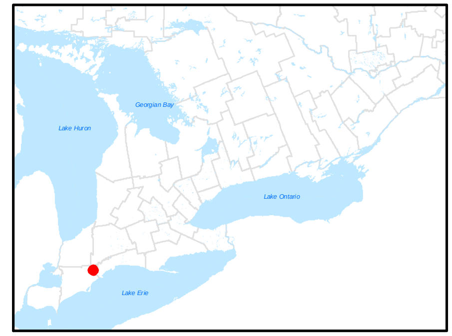
**Direction:** SE

**Location:**

**UTM:**

**Description:** Closeup of meadows, telephoto view from Johnston Line across the fence

**2203_photo2.JPG**


## Legend

Licence Boundary

Date of Image: 2006
(Before Licence Surrender)

Imagery used with permission from Ontario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 51
Site 151

1:8,000

N W E S

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

# Task 2 Appendix A Site Summary

## Site: 152

**Geographical Township:** LONDON

**Township or City:** MIDDLESEX CENTRE TP

**County or Region:** MIDDLESEX CO

**Geographical Area:** South West

**Pit or Quarry:** Pit

**Surrender Date:** 30/10/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ | **Other** | ☐ |

Agriculture or treed, pond

**Licenced Area:** 43.16

**Area to be Extracted:** 37.01

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ 64% |
| **Natural** | ☐ | **Agricultural** | ☑ 36% | **Other** | ☐ |

64% Open Space (including pond) 36% Agriculture

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☐ The large pond stands out in the landscape from an aerial perspective but this feature may serve a natural heritage function (waterfowl) and potentially water-based recreational activities.

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 17/07/2009

**Direction:** S

**Location:** SE of Vanneck Rd / 14 Mile Rd

**UTM:**

**Description:** View north of property from gate off 14-Mile Road.

**2320_S_photo 1.JPG**

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 17/07/2009

**Direction:** SE

**Location:** SE of Vanneck Rd / 14 Mile Rd

**UTM:**

**Description:** View of license area from 14-Mile Road.

**2320_SE_photo 2.JPG**

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 17/07/2009

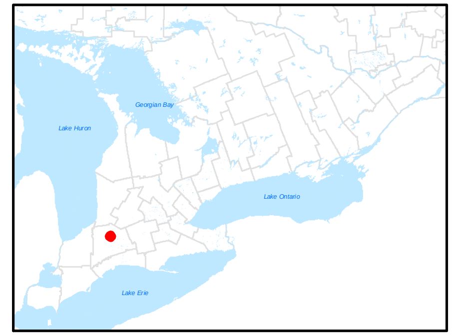
**Direction:** S

**Location:** SE of Vanneck Rd / 14 Mile Rd

**UTM:**

**Description:** View of sparsley treed western boundary from 14-Mile Road.

**2320_S_photo 3.JPG**


## Legend

Licence Boundary

Date of Image: 31/03/2006
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 52
Site 152

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap52_SAV152.mxd)
03/12/2009 -- 6:37:07 PM

# Task 2 Appendix A Site Summary

## Site: 153

**Geographical Township:** USBORNE

**Township or City:** MUNICIPALITY OF SOUTH HURON

**County or Region:** HURON COUNTY

**Geographical Area:** South West

**Pit or Quarry:** Pit

**Surrender Date:** 31/08/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☐ |
| **Natural** ☑ | **Agricultural** ☐ | **Other** ☐ |

Wildlife Habitat including pond (Site Plan)

**Licenced Area:** 11.24

**Area to be Extracted:** 10.24

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☐ |
| **Natural** ☑ 80% | **Agricultural** ☑ 20% | **Other** ☐ |

Pond with naturalized slopes and agriculture.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Adjacent residences.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 29/07/2009

**Direction:** South

**Location:** McTaggart Sideroad and 50m East of property driveway

**UTM:**

**Description:** Entire pond. Residence now present.

**4657_STN1- Entire Site.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 29/07/2009

**Direction:** South

**Location:** McTaggart Sideroad, 50m east of property entrance.

**UTM:**

**Description:** East side of pond.

**4657_STN 1 S- East side of pond.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 29/07/2009

**Direction:** South

**Location:** McTaggart Sideroad, 50m east of property entrance.

**UTM:**

**Description:** West side of pond.

**4657_ STN 1- West side of pond.JPG**



## Legend

Licence Boundary

Date of Image: 2006
(Before Licence Surrender)

Imagery used with permission from Ontario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 53
Site 153

1:8,000

N
W E
S

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

# Task 2 Appendix A Site Summary

## Site: 154

**Geographical Township:** DELAWARE

**Township or City:** LONDON

**County or Region:** MIDDLESEX CO **Geographical Area:** South West

**Pit or Quarry:** Pit **Surrender Date:** 25/09/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☑ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Park

**Licenced Area:** 8.7 **Area to be Extracted:** 6.4

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ 100% |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Fallow field - final landuse intended to be recreational park (site plan)

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Final landuse in site plan is recreational park. The surrounding area is a mixture of rural and agricultural landuse. Open greenspace would compliment the natural heritage system and provide open space access for nearby residents.

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

**Direction:** E

**Location:** South dead end of Tote Rd

**UTM:**

**Description:** View east of cultural meadow and interior lake / marsh


**2264_E_photo 1.JPG**

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

**Direction:** N

**Location:** South dead end of Tote Rd

**UTM:**

**Description:** View north of pit floor and cultural meadow

**2264_N_photo 2.JPG**

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

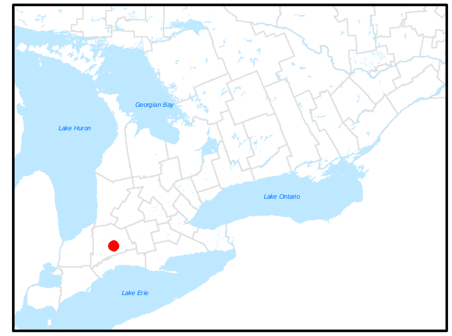
**Direction:** S

**Location:** South dead end of Tote Rd

**UTM:**

**Description:** View south along western boundary

**2264_S_photo 3.JPG**


## Legend

Licence Boundary

Date of Image: 03/05/2006
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 54
Site 154

1:8,000

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W E
S

December 3, 2009

Skelton Brumwell
& ASSOCIATES INC.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap54_SAV154.mxd)
03/12/2009 -- 6:32:01 PM

# Task 2 Appendix A Site Summary

## Site: 155

**Geographical Township:** WAWANOSH

**Township or City:** NORTH HURON TWP

**County or Region:** HURON COUNTY **Geographical Area:** South West

**Pit or Quarry:** Pit **Surrender Date:** 03/12/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ | **Other** | ☐ |

**Licenced Area:** 40 **Area to be Extracted:** 22.1

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ 100% | **Other** | ☐ |

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Yes - Agriculture

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 17/07/2009

**Direction:** East

**Location:** Reid Road

**UTM:**

**Description:** Looking east along Reid Road. Site within agricultural lands in background.

**18965_STN 1 W- Along Reid Rd.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 17/07/2009

**Direction:** Southeast

**Location:** Reid Road

**UTM:**

**Description:** Site rehabilitated to agriculture (corn field). Remenants of the pit are visibile in the background.

**18965_STN 1 SW- Corn field.JPG**



## Legend

Licence Boundary

Date of Image: 2006
(Before Licence Surrender)

Imagery used with permission fromOntario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 55
Site 155

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap55_SAV155.mxd)
03/12/2009 -- 6:31:13 PM

# Task 2 Appendix A Site Summary

## Site: 156

**Geographical Township:** WESTMINSTER

**Township or City:** LONDON

**County or Region:** MIDDLESEX CO **Geographical Area:** South West

**Pit or Quarry:** Pit **Surrender Date:** 18/07/2008 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☑ | **Agricultural** | ☐ | **Other** | ☐ |

Interim 100% Natural - Graded slopes planted with tree and shrub species to create native habitat. Future residential, open space or residential

**Licenced Area:** 2.45 **Area to be Extracted:** 2.45

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ 100% |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Appears to be partially natural heritage along vegetated berms, residential west of Cln Talbot Road, and still active / not yet rehabilitated east of Cln. Talbot Road. The site plan states that potential afteruses for this license include: residential, open space or recreational.

**Adjacent Land Uses:** Urban

**Adjacent Land Use Integration:** ☑ West of Cln Talbot Road yes - fits in with existing residential (unknown whether area west of Talbot rd was ever extracted - appears to be beyond extraction limit). Rehab plan for east of Talbot Road unknown.

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

**Direction:** E

**Location:** SE Colonel Talbot Rd / Byron Baseline Rd

**UTM:**

**Description:** View east through side gate off Cln. Talbot Rd

**18373_E_photo 1.JPG**

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

**Direction:** E

**Location:** SE Colonel Talbot Rd / Byron Baseline Rd

**UTM:**

**Description:** View east of vegetated berm on Cln. Talbot Rd

**18373_E_photo 2.JPG**

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

**Direction:** W

**Location:** SE Colonel Talbot Rd / Byron Baseline Rd

**UTM:**

**Description:** View west of vegetated berm and residential development

**18373_W_photo 3.JPG**

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

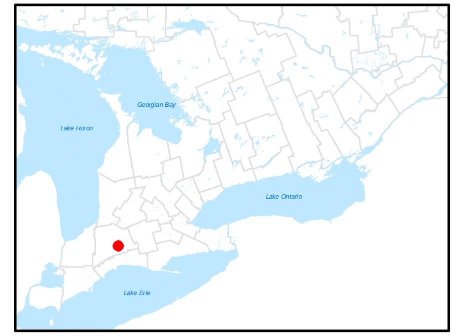
**Direction:** W

**Location:** SE Colonel Talbot Rd / Byron Baseline Rd

**UTM:**

**Description:** Steep slope west of Cln Talbot Rd.

**18373_W_photo 4.JPG**


## Legend

Licence Boundary

Date of Image: 03/05/2006
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 56
Site 156

1:8,000

December 3, 2009

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Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap56_SAV156.mxd)
03/12/2009 -- 6:25:53 PM

# Task 2 Appendix A Site Summary

## Site: 157

**Geographical Township:** AMABEL

**Township or City:** TOWN OF SOUTH BRUCE PENINSULA

**County or Region:** BRUCE COUNTY **Geographical Area:** South West

**Pit or Quarry:** Pit **Surrender Date:** 08/09/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☐ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☑ |

Not shown on Operational page.

**Licenced Area:** 37.9 **Area to be Extracted:** 22.4

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☑ 85% |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☐ |
| **Natural** ☑ 5% | **Agricultural** ☑ 10% | **Other** ☐ |

"Sauble Springs"
Landscaping supplier? Appears to be operating at rear.
Www.ronforbes.com

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☐ Unknown but none apparent.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 28/07/2009

**Direction:** South

**Location:** Entrance to site from Silver Lake Road

**UTM:**

**Description:** Entrance to site, now a landscaping supply operation.

**4914_STN 1 S- Entrance and buildings.JPG**

---

**Taken By:** Kyle Fleming, SBA

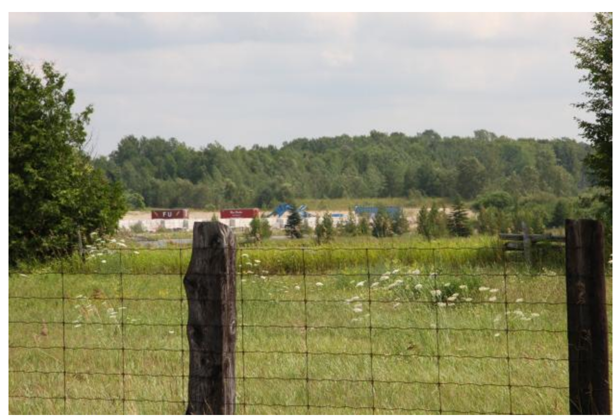
**Date of Photo:** 28/07/2009

**Direction:** Southeast

**Location:** Approximately 500m west of entrance on Silver Lake Road

**UTM:**

**Description:** Looking at rehabilitated areas on west half of site.



**4914_STN 2 NE- into site from Silver Lake Rd.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 28/07/2009

**Direction:** Southwest

**Location:** 200m east of entrance on Silver Lake Road

**UTM:**

**Description:** Looking into site. Ponds visible and landscape materials in background. Lands in foreground and ponds were rehabilitated.

**4914_STN 3 S- Ponds in NE part of site.JPG**



**Legend**

Licence Boundary

Date of Image: 03/06/2005
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 57
Site 157

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

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Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap57_SAV157.mxd)
03/12/2009 -- 6:24:06 PM

# Task 2 Appendix A Site Summary

## Site: 158

**Geographical Township:** LONDON

**Township or City:** LONDON

**County or Region:** MIDDLESEX CO

**Geographical Area:** South West

**Pit or Quarry:** Pit

**Surrender Date:** 29/11/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☑ |
| **Institutional** ☐ | **Industrial** ☑ | **Open Space** ☐ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Industrial and/or Commercial in conformity with City of London Official Plan (Site Plan)

**Licenced Area:** 40.99

**Area to be Extracted:** 37.2

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☑ 100% | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☐ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Residential development and cultural development (the latter an intermim use to prevent erosion until ready for residential development)

**Adjacent Land Uses:** Urban

**Adjacent Land Use Integration:** ☑ Residential development integrates well with surrounding area.

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

**Direction:** NW

**Location:** West of Fashawe Park Rd E / Clarke Rd

**UTM:**

**Description:** Northwest berm along Fanshawe Park Rd

**2179_NW_photo 1.JPG**

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

**Direction:** W

**Location:** West of Fashawe Park Rd E / Clarke Rd

**UTM:**

**Description:** View west of cultural meadow down partially constructed Cedarpark Crescent

**2179_W_photo 2.JPG**

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

**Direction:** E

**Location:** West of Fashawe Park Rd E / Clarke Rd

**UTM:**

**Description:** View east of berm that bisects the site

**2179_E_photo 3.JPG**

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

**Direction:** SE

**Location:** West of Fashawe Park Rd E / Clarke Rd

**UTM:**

**Description:** Southern extent of residential development looking southeast

**2179_SE_photo 4.JPG**

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

**Direction:** S

**Location:** West of Fashawe Park Rd E / Clarke Rd

**UTM:**

**Description:** Evidence of ponding in southern end of residential development

**2179_S_photo 5.JPG**

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

**Direction:** E

**Location:** West of Fashawe Park Rd E / Clarke Rd

**UTM:**

**Description:** Planned rsidential development


**2179_E_photo 6.JPG**

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 10/08/2009

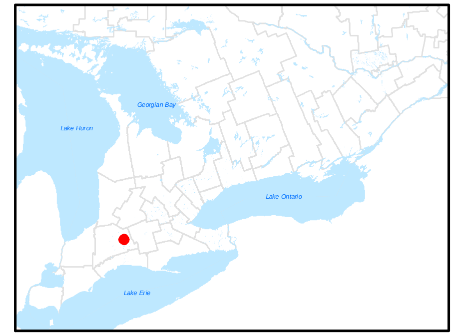
**Direction:** W

**Location:** West of Fashawe Park Rd E / Clarke Rd

**UTM:**

**Description:** Fallow field west of Cedarhollow Blvd

**2179_W_photo 7.JPG**


## Legend

Licence Boundary

Date of Image: 03/05/2006
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 58
Site 158

1:8,000

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December 3, 2009

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Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap58_SAV158.mxd)
03/12/2009 -- 6:22:16 PM

# Task 2 Appendix A Site Summary

## Site: 159

**Geographical Township:** HURON

**Township or City:** HURON-KINLOSS TWP

**County or Region:** BRUCE COUNTY

**Geographical Area:** South West

**Pit or Quarry:** Pit

**Surrender Date:** 15/05/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☑ | **Agricultural** | ☐ | **Other** | ☐ |

Pond with grassed slopes.

**Licenced Area:** 15.3

**Area to be Extracted:** 12

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☑ 50% | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ 50% |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Residential development surrounding pond.

**Adjacent Land Uses:** Urban

**Adjacent Land Use Integration:** ☑ Integration with adjacent residential communities. Likely use as a selling feature.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 17/07/2009

**Direction:** East

**Location:** Southwest corner of pond

**UTM:**

**Description:** Looking east toward southeast corner of pond. Recreation trail visible going around pond. Planting completed at edge.

**4529_STN 1 E- South edge of pond.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 17/07/2009

**Direction:** Northeast

**Location:** Southwest corner of pond

**UTM:**

**Description:** Southwest corner and west side of pond. Residential development along edge with recreation trail and plantings.

**4529_STN 1 NE- west edge pond.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 17/07/2009

**Direction:** Southwest

**Location:** Northwest corner of pond and Kin-Huron Road

**UTM:**

**Description:** Looking toward northwest corner of pond. Residential development, island and bridge visible.

**4529_STN 2 S- NW corner of pond.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 17/07/2009

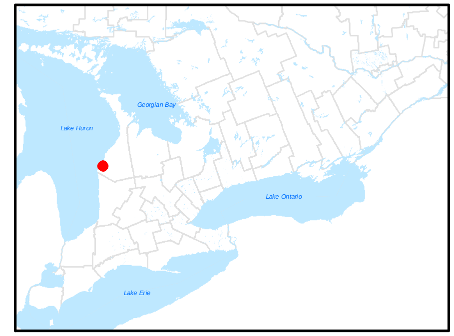
**Direction:** Southeast

**Location:** Northwest corner of pond and Kin-Huron Road

**UTM:**

**Description:** Looking toward northeast corner of pond. Area at top of bank has been graded for construction.

**4529_STN 2 SE- NE corner of pond.JPG**


## Legend

Licence Boundary

Date of Image: 06/09/2005
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 59
Site 159

1:8,000

December 3, 2009

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SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap59_SAV159.mxd)
03/12/2009 -- 6:21:00 PM

# Task 2 Appendix A Site Summary

## Site: 160

**Geographical Township:** AMABEL

**Township or City:** TOWN OF SOUTH BRUCE PENINSULA

**County or Region:** BRUCE COUNTY  **Geographical Area:** South West

**Pit or Quarry:** Pit  **Surrender Date:** 18/09/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☐ |
| **Natural** ☐ | **Agricultural** ☑ | **Other** ☐ |

(Site Plan)

**Licenced Area:** 13.76  **Area to be Extracted:** 6

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ 33% |
| **Natural** ☐ | **Agricultural** ☑ 67% | **Other** ☐ |

Vacant, pasture? - limited visibility to rear of property

**Adjacent Land Uses:** Remote

**Adjacent Land Use Integration:** ☐ No, left vacant

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 28/07/2009

**Direction:** North

**Location:** Entrance to site from Boat Lake Road

**UTM:**

**Description:** Entrance to site. Existing building visible on non-extracted part of property.

**4884_STN 1 N- Entrance.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 28/07/2009

**Direction:** North

**Location:** Entrance to site from Boat Lake Road.

**UTM:**

**Description:** Looking into the site. Old field vegetation established on visible portions of rehabilitated site.

**4884_STN 1 N- Site Part B.JPG**



## Legend

Licence Boundary

Date of Image: 03/06/2005
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 60
Site 160

1:8,000

December 3, 2009

Skelton Brumwell & ASSOCIATES INC.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap60_SAV160.mxd)
03/12/2009 -- 6:18:44 PM

# Task 2 Appendix A Site Summary

## Site: 161

**Geographical Township:** NISSOURI

**Township or City:** THAMES CENTRE M

**County or Region:** MIDDLESEX CO **Geographical Area:** South West

**Pit or Quarry:** Pit **Surrender Date:** 24/09/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☑ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

**Licenced Area:** 18.2 **Area to be Extracted:** 13.7

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☑ 100% | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Recreation

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ The large pond does not fit in with the local landscape, which is dominated by agricultural and forest patches. However, rehabilitation of this license does augment the local natural heritage system by providing both aquatic and terrestrial habitat for wildlife and recreational activities.

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 17/07/2009

**Direction:** E

**Location:** East Nissouri Rd

**UTM:**

**Description:** Property not visible from public access but this for sale sign was at road.


**2172_E_photo 1.JPG**



## Legend

Licence Boundary

Date of Image: 31/03/2006
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 61
Site 161

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap61_SAV161.mxd)
03/12/2009 -- 5:42:55 PM

# Task 2 Appendix A Site Summary

## Site: 162

**Geographical Township:** KINLOSS

**Township or City:** HURON-KINLOSS TWP

**County or Region:** BRUCE COUNTY

**Geographical Area:** South West

**Pit or Quarry:** Pit

**Surrender Date:** 25/07/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☑ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Recreational Pond (Site Plan)

**Licenced Area:** 14.6

**Area to be Extracted:** 12.3

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☑ 100% | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Golf Course (surrounding pond).
"Black Horse Golf & Country Club"

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Surrounding land natural heritage (woodlands/wetlands) & agriculture. Serves community recreational needs.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 17/07/2009

**Direction:** Southeast

**Location:** Access Road from Bruce Road 1

**UTM:**

**Description:** Looking southeast at pond. Dense plantings completed. Active pit in background on adjacent property.

**4551_STN 1 SE- Pond.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 17/07/2009

**Direction:** Southeast

**Location:** Access Road from Bruce Road 1.

**UTM:**

**Description:** Golf green overlooking pond.

**4551_STN 1 SE- Pond and golf green.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 17/07/2009

**Direction:** East

**Location:** Access Road along Bruce Road 1 at top of hill.

**UTM:**

**Description:** Overlooking pond and golf course surrounding pond.  Active pit visible in background.

**4551_STN 2 E- Pond overhead.JPG**



## Legend

Licence Boundary

Date of Image: 14/07/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 62
Site 162

N W E S

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap62_SAV162.mxd)
04/12/2009 -- 10:02:38 AM

# Task 2 Appendix A Site Summary

## Site: 163

**Geographical Township:** SARAWAK

**Township or City:** GEORGIAN BLUFFS TWP

**County or Region:** GREY COUNTY **Geographical Area:** South West

**Pit or Quarry:** Pit **Surrender Date:** 25/10/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ | **Other** | ☐ |

Light forestation for rough pasture (Site Plan)

**Licenced Area:** 12.69 **Area to be Extracted:** 8.79

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ 100% | **Other** | ☐ |

Vacant

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☐ None visible

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 28/07/2009

**Direction:** NW

**Location:** Entrance from Grey Road 1

**UTM:**

**Description:** Gated entrance to site.

**16505_STN 1 NW- Entrance.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 28/07/2009

**Direction:** North

**Location:** Entrance at Grey Road 1

**UTM:**

**Description:** Driveway to site from Grey Road 1.

**16505_ STN 1 N- Driveway.JPG**



## Legend

Licence Boundary

Date of Image: 08/06/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 63
Site 163

1:8,000

N
W E
S

December 3, 2009

Skelton Brumwell & ASSOCIATES INC.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap63_SAV163.mxd)
04/12/2009 -- 10:08:29 AM

# Task 2 Appendix A Site Summary

## Site: 164

**Geographical Township:** WATERLOO

**Township or City:** KITCHENER

**County or Region:** WATERLOO R    **Geographical Area:** South West

**Pit or Quarry:** Pit    **Surrender Date:** 14/11/2008 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| Residential ☐ | Recreational ☐ | Commercial ☐ |
| Institutional ☐ | Industrial ☐ | Open Space ☐ |
| Natural ☐ | Agricultural ☑ | Other ☐ |

Until future subdivision plans are finalized.

**Licenced Area:** 24.33    **Area to be Extracted:** 21.38

**Existing Land Use:**

| | | |
|---|---|---|
| Residential ☑ 100% | Recreational ☐ | Commercial ☐ |
| Institutional ☐ | Industrial ☐ | Open Space ☐ |
| Natural ☐ | Agricultural ☐ | Other ☐ |

Residential development

**Adjacent Land Uses:** Urban

**Adjacent Land Use Integration:** ☑

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 15/07/2009

**Direction:** NE

**Location:** N of Bleams Road

**UTM:**

**Description:** northeast corner, residential development north of hydro corridor

**5528_NE_photo 1.JPG**

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 15/07/2009

**Direction:** W

**Location:** N of Bleams Road

**UTM:**

**Description:** View west of main residential development

**5528_W_photo 2.JPG**

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 15/07/2009

**Direction:** NW

**Location:** N of Bleams Road

**UTM:**

**Description:** Pond feature in northwest corner of site

**5528_NW_photo 3.JPG**


## Legend

Licence Boundary

Date of Image: 27/04/2006
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 64
Site 164

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap64_SAV164.mxd)
04/12/2009 -- 10:14:16 AM

# Task 2 Appendix A Site Summary

## Site: 165

**Geographical Township:** GARAFRAXA

**Township or City:** EAST GARAFRAXA TWP

**County or Region:** DUFFERIN COUNTY **Geographical Area:** South West

**Pit or Quarry:** Pit **Surrender Date:** 27/06/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☐ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☑ |

Not specified or illegible.

**Licenced Area:** 40.47 **Area to be Extracted:** 35

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ 60% |
| **Natural** ☐ | **Agricultural** ☑ 40% | **Other** ☐ |

Vacant

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☐ Land vacant - no integration with surrounding land uses. Now private residence.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 19/09/2009

**Direction:** North

**Location:** East limit of property at driveway

**UTM:**

**Description:** New residence being constructed in southwest corner of site.

**STN 1 N- New residence.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 19/08/2009

**Direction:** Northeast

**Location:** Fenced entrance on 18th Line

**UTM:**

**Description:** Middle of site. Stockpiles within rehabilitated area, do not appear to be related to any active operation on the site.

**STN 2- N - Stockpile.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 19/08/2009

**Direction:** North

**Location:** Gated entrance on 18th Line

**UTM:**

**Description:** Looking north into front area of site.

**STN 2 N- Mid-site.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 19/08/2009

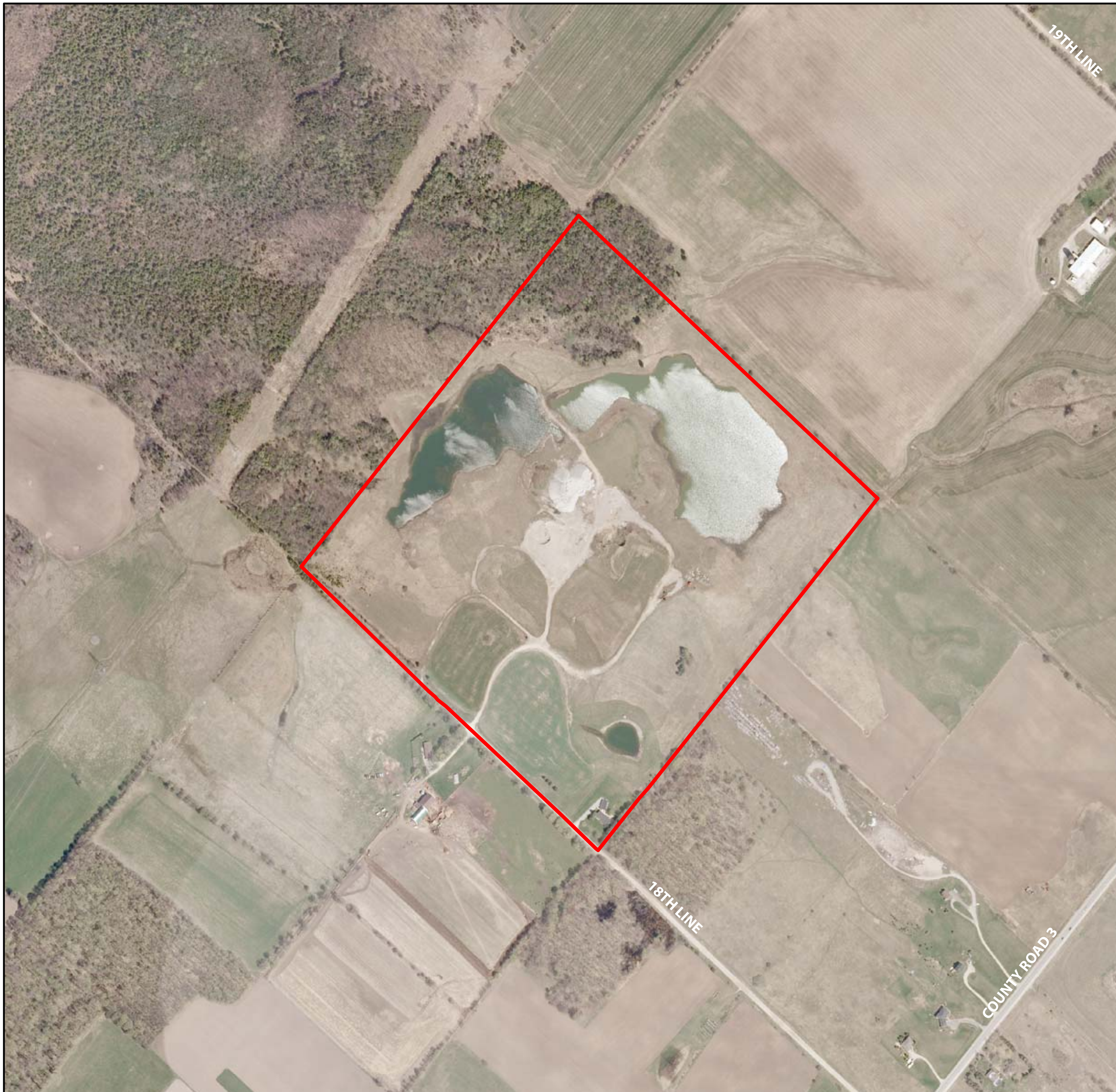
**Direction:** Northeast

**Location:** Gated entrance on 18th Line

**UTM:**

**Description:** Pond in west part of site, just north of new residence.

**STN 2- NW- Pond.JPG**





**Legend**

Licence Boundary

Date of Image: 2006
(Before Licence Surrender)

Imagery used with permission from Ontario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 65
Site 165

1:8,000

N W E S

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap65_SAV165.mxd)
04/12/2009 -- 10:30:23 AM

# Task 2 Appendix A Site Summary

## Site: 166

**Geographical Township:** BEVERLY

**Township or City:** HAMILTON

**County or Region:** HAMILTON-WENTWORTH R **Geographical Area:** Greenbelt

**Pit or Quarry:** Quarry **Surrender Date:** 16/07/1998 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| Residential | ☐ | Recreational | ☐ | Commercial | ☐ |
| Institutional | ☐ | Industrial | ☐ | Open Space | ☑ |
| Natural | ☐ | Agricultural | ☐ | Other | ☐ |

Not specified

**Licenced Area:** 3 **Area to be Extracted:** 2.8

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| Residential | ☐ | Recreational | ☐ | Commercial | ☐ |
| Institutional | ☐ | Industrial | ☐ | Open Space | ☑ 60% |
| Natural | ☐ | Agricultural | ☑ 40% | Other | ☐ |

Lake in centre of former pit (not visible/observed from road), surrounded by hay meadow.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Well integrated

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 10/07/2009

**Direction:** W

**Location:**

**UTM:**

**Description:** Panorama from Woodhill Road

**5522_photo1.JPG**

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 10/07/2009

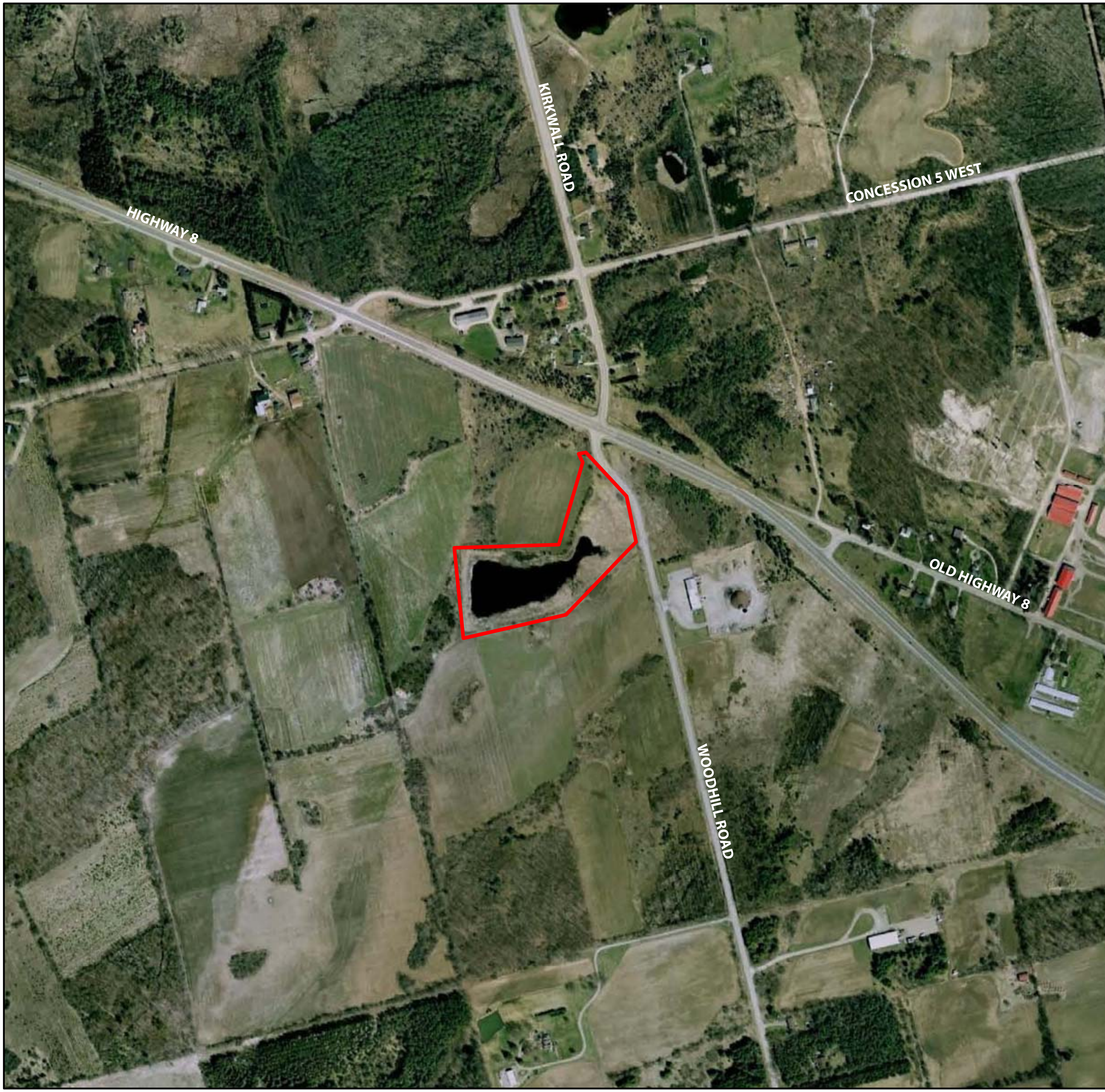
**Direction:** W

**Location:**

**UTM:**

**Description:** General view from Woodhill Road

**5522_photo2.JPG**





**Legend**

Licence Boundary

Date of Image: 05/03/2005
(After Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 66
Site 166

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap66_SAV166.mxd)
04/12/2009 -- 10:31:24 AM

# Task 2 Appendix A Site Summary

## Site: 167

**Geographical Township:** WALPOLE

**Township or City:** HALDIMAND COUNTY

**County or Region:** HALDIMAND-NORFOLK R **Geographical Area:** South West

**Pit or Quarry:** Quarry **Surrender Date:** 24/10/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☑ | **Recreational** | ☑ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

**Licenced Area:** 58.61 **Area to be Extracted:** 51.34

**Existing Land Use:**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Residential** | ☑ | 10% | **Recreational** | ☐ | **Commercial** | ☐ | |
| **Institutional** | ☐ | | **Industrial** | ☐ | **Open Space** | ☑ | 90% |
| **Natural** | ☐ | | **Agricultural** | ☐ | **Other** | ☐ | |

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 10/07/2009

**Direction:** S

**Location:**

**UTM:**

**Description:** General view of lake.

**3762_photo1.JPG**

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 10/07/2009

**Direction:** S

**Location:**

**UTM:**

**Description:** General view of lake.

**3762_photo2.JPG**

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 10/07/2009

**Direction:** E

**Location:**

**UTM:**

**Description:** Agriculture on W side of lake.

**3762_photo3.JPG**

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 10/07/2009

**Direction:** SE

**Location:**

**UTM:**

**Description:** Agriculture on W side of lake.

**3762_photo4.JPG**



## Legend

Licence Boundary

Date of Image: 2006
(Before Licence Surrender)

Imagery used with permission from Ontario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 67
Site 167

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap67_SAV167.mxd)
04/12/2009 -- 10:35:34 AM

# Task 2 Appendix A Site Summary

## Site: 168

**Geographical Township:** ESQUESING

**Township or City:** HALTON HILLS

**County or Region:** HALTON R **Geographical Area:** NEC

**Pit or Quarry:** Pit **Surrender Date:** 17/10/2008 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☑ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Estate residential subject to NEC approval.

**Licenced Area:** 42.49 **Area to be Extracted:** 27.1

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ 100% |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Old field meadow

**Adjacent Land Uses:** Urban

**Adjacent Land Use Integration:** ☐ Not integrated, appears an isolated open area (awaiting NEC approval for development)

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 28/07/2009

**Direction:** SW

**Location:** From Hwy 7

**UTM:**

**Description:** General view - Estate subdivision proposed subject to NEC approval.

**5687_photo1.JPG**



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 68
Site 168

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap68_SAV168.mxd)
04/12/2009 -- 10:39:46 AM

# Task 2 Appendix A Site Summary

## Site: 169

**Geographical Township:** EAST FLAMBOROUGH

**Township or City:** HAMILTON

**County or Region:** HAMILTON-WENTWORTH R **Geographical Area:** NEC

**Pit or Quarry:** Pit **Surrender Date:** 28/11/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ | **Other** | ☐ |

Slopes to be planted with oats, legumes and/or alfalfa for stability. Oats, seed legumes and alafalfa crops to be planted and plowed under for at least 3 years to increase soil fertility and structure.

**Licenced Area:** 8.42 **Area to be Extracted:** 6.72

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ 100% | **Other** | ☐ |

Not able to directly view (no access) but appears to be fallow field, intended afteruse is agriculture.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ If currently utilized for agriculture (as is the intended final landuse), yes this site will fit in well with the surrounding local landscape, which is dominated by agriculture.

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 13/09/2009

**Direction:** E

**Location:** East of Greenspring Rd

**UTM:**

**Description:** View east from Greenspring Road, fallow field in background (beyond corn) is the license area.

**5682_E_photo 1.JPG**



## Legend

Licence Boundary selection

Date of Image: 05/03/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 69
Site 169

1:8,000

December 3, 2009

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SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap69_SAV169.mxd)
04/12/2009 -- 10:43:41 AM

# Task 2 Appendix A Site Summary

## Site: 170

**Geographical Township:** NASSAGAWEYA

**Township or City:** MILTON

**County or Region:** HALTON R  **Geographical Area:** NEC

**Pit or Quarry:** Quarry  **Surrender Date:** 19/07/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| Residential ☐ | Recreational ☑ | Commercial ☐ |
| Institutional ☐ | Industrial ☐ | Open Space ☐ |
| Natural ☐ | Agricultural ☐ | Other ☐ |

Intended for public recreation as addition to Kelso-Glen Eden Conservation Area.

**Licenced Area:** 93.65  **Area to be Extracted:** 74.03

**Existing Land Use:**

| | | |
|---|---|---|
| Residential ☐ | Recreational ☑ 100% | Commercial ☐ |
| Institutional ☐ | Industrial ☐ | Open Space ☐ |
| Natural ☐ | Agricultural ☐ | Other ☐ |

Lake with rehabilitated edges.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:**

**Direction:** from N to SE

**Location:** from W bank of lake

**UTM:**

**Description:** Successive photos of lake and shoreline

5496_photo1.JPG

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:**

**Direction:** from N to SE

**Location:** from W bank of lake

**UTM:**

**Description:** Successive photos of lake and shoreline

5496_photo2.JPG

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:**

**Direction:** from N to SE

**Location:** from W bank of lake

**UTM:**

**Description:** Successive photos of lake and shoreline

**5496_photo3.JPG**

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:**

**Direction:** from N to SE

**Location:** from W bank of lake

**UTM:**

**Description:** Successive photos of lake and shoreline

**5496_photo4.JPG**



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 70
Site 170

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap70_SAV170.mxd)
04/12/2009 -- 10:48:32 AM

# Task 2 Appendix A Site Summary

## Site: 171

**Geographical Township:** USBORNE

**Township or City:** SOUTH HURON M

**County or Region:** HURON CO

**Geographical Area:** South West

**Pit or Quarry:** Pit

**Surrender Date:** 14/12/2005 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

- **Residential** ☐
- **Recreational** ☑
- **Commercial** ☐
- **Institutional** ☐
- **Industrial** ☐
- **Open Space** ☐
- **Natural** ☐
- **Agricultural** ☐
- **Other** ☐

**Licenced Area:** 16.13

**Area to be Extracted:** 16.04

**Existing Land Use:**

- **Residential** ☐
- **Recreational** ☐
- **Commercial** ☐
- **Institutional** ☐
- **Industrial** ☐
- **Open Space** ☑ 100%
- **Natural** ☐
- **Agricultural** ☐
- **Other** ☐

Open Space - no apparent recreational use.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 29/07/2009

**Direction:** West

**Location:** Mid point of site along County Road 23

**UTM:**

**Description:** South part of site. Dense field vegetation. Pond visible in background.

**4708_STN 1 W- South part of site.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 29/07/2009

**Direction:** Northwest

**Location:** Mid point of site along County Road 23

**UTM:**

**Description:** Approximate middle of site.

**4708_STN 1 NW- Mid point of site.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 29/07/2009

**Direction:** Northwest

**Location:** Mid point of site along County Road 23

**UTM:**

**Description:** North part of site. Heavily vegetated with shrub and trees becoming established.

**4708_STN 1 North- North part of site.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 29/07/2009

**Direction:** West

**Location:** Mid point of site along County Road 23

**UTM:**

**Description:** Pond within site. Well vegetated and stable.

**4708_STN 1 W- Pond.JPG**



## Legend

Licence Boundary

Date of Image: 2006
(After Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 71
Site 171

1:8,000

December 3, 2009

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SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap71_SAV171.mxd)
04/12/2009 -- 10:52:20 AM

# Task 2 Appendix A Site Summary

## Site: 172

**Geographical Township:** TORONTO

**Township or City:** CITY OF MISSISSAUGA

**County or Region:** PEEL REGION **Geographical Area:** GTA

**Pit or Quarry:** Quarry **Surrender Date:** 13/11/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

- [ ] Residential
- [ ] Recreational
- [ ] Commercial
- [ ] Institutional
- [ ] Industrial
- [x] Open Space
- [ ] Natural
- [ ] Agricultural
- [ ] Other

Not Specified (Site Plan)

**Licenced Area:** 53.5 **Area to be Extracted:** 49

**Existing Land Use:**

- [ ] Residential
- [ ] Recreational
- [ ] Commercial
- [ ] Institutional
- [x] Industrial 100%
- [ ] Open Space
- [ ] Natural
- [ ] Agricultural
- [ ] Other

Cleared and graded, "Mill Creek Business Park" Orlando Corp.

**Adjacent Land Uses:** Urban

**Adjacent Land Use Integration:** [x] Business parks NW and NE of property.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 08/07/2009

**Direction:** NE

**Location:** Mill Creek/Brittania Road W

**UTM:**

**Description:** Construction of Mill Creek Business Park in Southern part of surrendered licence. First building on site visible in background

6515 NE STN 1.jpg

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 08/07/2009

**Direction:** SE

**Location:** North end Mill Creek in Mill Creek business Park Looking SE.

**UTM:**

**Description:** Construction underway at Mill Creek Business Park within North part of surrendered licence.

6515 SE STN 2.jpg



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 72
Site 172

1:8,000

December 3, 2009

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SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap72_SAV172.mxd)
04/12/2009 -- 11:00:50 AM

# Task 2 Appendix A Site Summary

## Site: 173

**Geographical Township:** TORONTO

**Township or City:** CITY OF MISSISSAUGA

**County or Region:** PEEL REGION **Geographical Area:** GTA

**Pit or Quarry:** Quarry **Surrender Date:** 15/05/1998 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☑ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Urban Development, primarily residential (Site Plan)

**Licenced Area:** 68 **Area to be Extracted:** 60

**Existing Land Use:**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Residential** | ☑ | 62% | **Recreational** | ☑ | 15% | **Commercial** | ☑ | 13% |
| **Institutional** | ☑ | 5% | **Industrial** | ☐ | | **Open Space** | ☑ | 5% |
| **Natural** | ☐ | | **Agricultural** | ☐ | | **Other** | ☐ | |

**Adjacent Land Uses:** Urban

**Adjacent Land Use Integration:** ☑ With commericial and residential.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 08/07/2009

**Direction:** Unknown

**Location:** Residential

**UTM:**

**Description:** Residential subdivision within the site.

6521_STN 1 - Residential.jpg

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 08/07/2009

**Direction:** Southeast

**Location:** Parking area adjacent to school off Hillcrest Ave.

**UTM:**

**Description:** Looking southwest at school.

6521_STN 2 SE- Institutional.jpg

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 08/07/2009

**Direction:** Northwest

**Location:** Corner of Elmcreek Rd and Dundas Street West

**UTM:**

**Description:** Commerical area in southwest portion of site.

6521_STN 3 NW- Commercial.jpg

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 08/07/2009

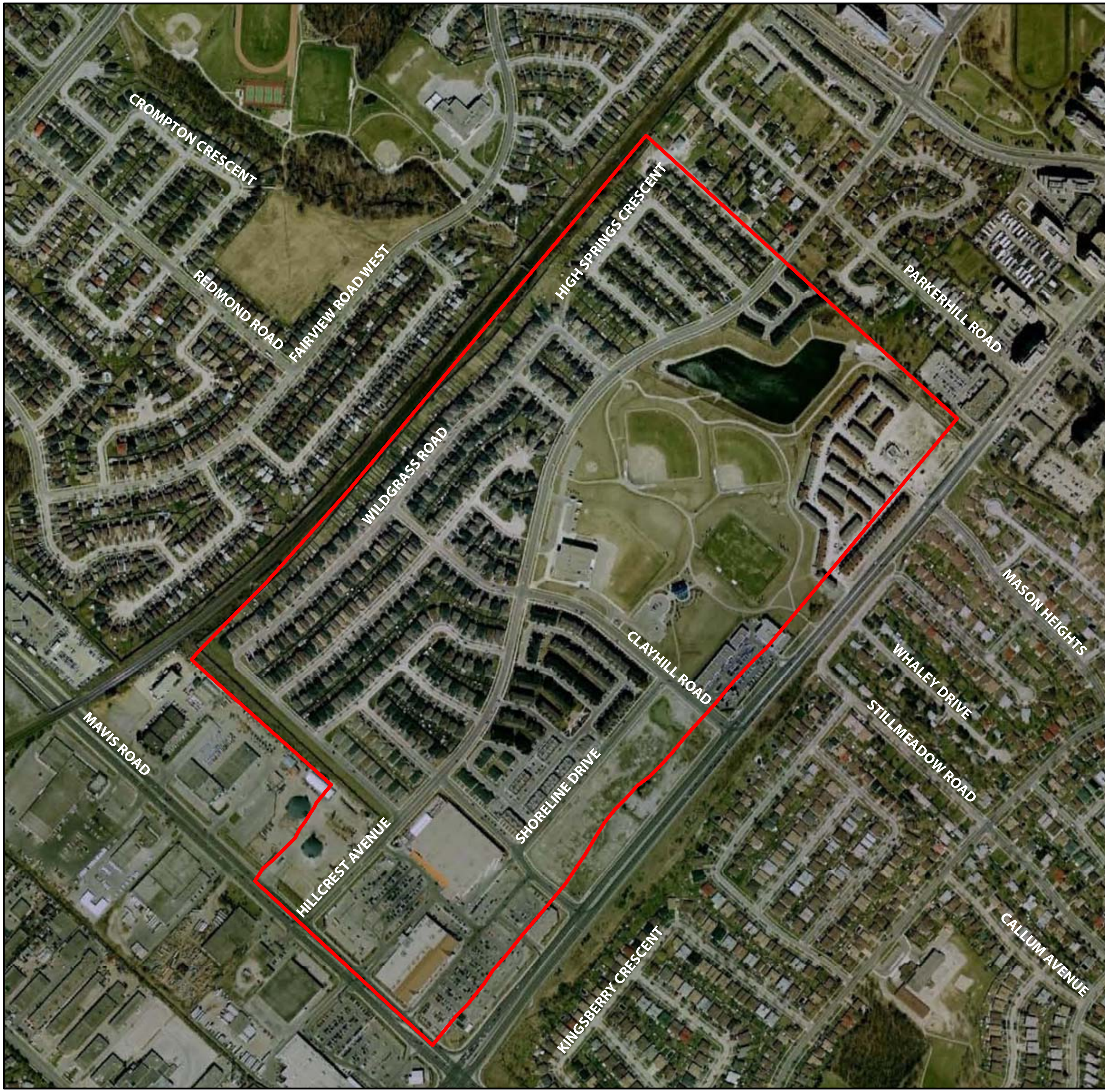
**Direction:** Southeast

**Location:** Northwest corner of SWM pond.

**UTM:**

**Description:** Looking southeast over Stormwater management pond. Residential development visible in background.


6521_STN 4 SE- SWM pond.jpg





## Legend

Licence Boundary

Date of Image: 05/03/2005
(After Licence Surrender)

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**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 73
Site 173

1:8,000

December 3, 2009

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SAVANTA



## Legend

Licence Boundary

Date of Image: 1995
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 73b
Site 173
1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap73_SAV173_1995.mxd)
04/12/2009 -- 1:42:44 PM

# Task 2 Appendix A Site Summary

## Site: 174

**Geographical Township:** SAUGEEN

**Township or City:** SAUGEEN SHORES

**County or Region:** BRUCE CO **Geographical Area:** South West

**Pit or Quarry:** Pit **Surrender Date:** 12/04/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☐ |
| **Natural** ☐ | **Agricultural** ☑ | **Other** ☐ |

**Licenced Area:** 35.57 **Area to be Extracted:** 16.8

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☐ |
| **Natural** ☑ 50% | **Agricultural** ☑ 50% | **Other** ☐ |

Pasture and vacant lands.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Pasture land/natural regeneration.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 28/07/2009

**Direction:** South

**Location:** Corner Links Sideroad and 14th Concession

**UTM:**

**Description:** Looking into site. Fully grassed with shrub and trees becoming established.

**4977_STN 1 S- Rehabilitated area.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 28/07/2009

**Direction:** Southwest

**Location:** Corner Links Sideroad and 14th Concession

**UTM:**

**Description:** Western part of site along Links Sideroad.

**4977_STN 1 SW- Rehabilitated area along Links Sideroad.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 28/07/2009

**Direction:** Southeast

**Location:** Corner Links Sideroad and 14th Concession

**UTM:**

**Description:** Rehabilitated area and existing building.

**4977_STN 1 SE- Rehabilitated area and existing buildings.JPG**



## Legend

Licence Boundary

Date of Image: 09/07/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 74
Site 174

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap74_SAV174.mxd)
04/12/2009 -- 11:25:58 AM

# Task 2 Appendix A Site Summary

## Site: 175

**Geographical Township:** MALAHIDE

**Township or City:** MALAHIDE TP

**County or Region:** ELGIN CO **Geographical Area:** South West

**Pit or Quarry:** Pit **Surrender Date:** 20/06/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ | **Other** | ☐ |

**Licenced Area:** 11.28 **Area to be Extracted:** 9.05

**Existing Land Use:**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ | 100% | **Other** | ☐ |

Agriculture

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Well integrated local landscape - corn crop.

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 18/07/2009

**Direction:** SW

**Location:** SW Calton Ln / Rommel Rd

**UTM:**

**Description:** View southwest from Rommel Rd

**17646_SW_photo 1.JPG**

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 18/07/2009

**Direction:** N

**Location:** SW Calton Ln / Rommel Rd

**UTM:**

**Description:** View north towards Calton Ln.

**17646_N_photo 2.JPG**



## Legend

Licence Boundary

Date of Image: 29/03/2006
(Before Licence Surrender)

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**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 75
Site 175

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap75_SAV175.mxd)
04/12/2009 -- 11:26:28 AM

# Task 2 Appendix A Site Summary

## Site: 176

**Geographical Township:** KING

**Township or City:** KING TWP

**County or Region:** YORK REGION **Geographical Area:** Greenbelt

**Pit or Quarry:** Pit **Surrender Date:** 23/04/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Undetermined

**Licenced Area:** 42.38 **Area to be Extracted:** 34.9

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ 100% |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration** ☑ Very good - water body used historically for water ski club



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

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**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 76
Site 176

1:8,000

December 3, 2009

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Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap76_SAV176.mxd)
04/12/2009 -- 12:00:29 PM

# Task 2 Appendix A Site Summary

## Site: 177

**Geographical Township:** VAUGHAN

**Township or City:** CITY OF VAUGHAN

**County or Region:** YORK REGIONS **Geographical Area:** ORM

**Pit or Quarry:** Pit **Surrender Date:** 04/05/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Potential for Industrial Use if approvals (Site Plan).

**Licenced Area:** 7.8 **Area to be Extracted:** 6.9

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☑ 100% | **Open Space** ☐ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Prepared for development

**Adjacent Land Uses:** Urban

**Adjacent Land Use Integration** ☑ Continuous with adjacent surrendered licence north and south (Site No. 178)



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

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**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 77
Site 177

1:8,000

December 3, 2009

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Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap77_SAV177.mxd)
04/12/2009 -- 12:09:52 PM



## Legend

Licence Boundary

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**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 77b
Site 177

1:8,000

December 3, 2009

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Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap77_SAV177_1995.mxd)
04/12/2009 -- 1:44:40 PM

# Task 2 Appendix A Site Summary

## Site: 178

**Geographical Township:** VAUGHAN

**Township or City:** VAUGHAN

**County or Region:** YORK R **Geographical Area:** ORM

**Pit or Quarry:** Pit **Surrender Date:** 04/05/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Potential industrial uses with approvals

**Licenced Area:** 36.98 **Area to be Extracted:** 32.5

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☑ 100% | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Site being prepared for development.

**Adjacent Land Uses:** Urban

**Adjacent Land Use Integration:** ☐ No yet, under development

---

**Taken By:** Anne Guiot, SBA

**Date of Photo:** 06/08/2009

**Direction:** Northeast

**Location:** Along south boundary of pit

**UTM:**

**Description:** Preparation for development.

**6513_STN1 NE- South boundary.JPG**

---

**Taken By:** Anne Guiot, SBA

**Date of Photo:** 06/08/2009

**Direction:** West

**Location:** Southeast corner of pit

**UTM:**

**Description:** Infilling pit for development.

**6513_STN2 W- SE corner.JPG**

**Taken By:** Anne Guiot, SBA

**Date of Photo:** 06/08/2009

**Direction:** North

**Location:** East side of pit

**UTM:**

**Description:** Infilling pit for development.

**6513_STN3 N- East side pit.JPG**



## Legend

178

Date of Image: 05/03/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 78
Site 178

1:8,000

December 3, 2009

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Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap78_SAV178.mxd)
04/12/2009 -- 12:16:55 PM



## Legend

Licence Boundary

Date of Image: 1995
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 78b
Site 178

1:8,000

N W E S

December 3, 2009

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Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap78_SAV178_1995.mxd)
04/12/2009 -- 1:46:57 PM

# Task 2 Appendix A Site Summary

## Site: 179

**Geographical Township:** CLINTON

**Township or City:** LINCOLN

**County or Region:** NIAGARA R   **Geographical Area:** NEC

**Pit or Quarry:** Quarry   **Surrender Date:** 10/09/2004 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

- **Residential** ☐ **Recreational** ☐ **Commercial** ☐
- **Institutional** ☐ **Industrial** ☐ **Open Space** ☐
- **Natural** ☐ **Agricultural** ☑ **Other** ☐

Agriculture, or other use as approved by MNR

**Licenced Area:** 31.5   **Area to be Extracted:** 25.6

**Existing Land Use:**

- **Residential** ☐ **Recreational** ☐ **Commercial** ☐
- **Institutional** ☐ **Industrial** ☐ **Open Space** ☐
- **Natural** ☑ 80% **Agricultural** ☑ 20% **Other** ☐

Forest - not extracted by Walker Industries (historically was extracted)

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ This license has remained natural heritage and compliments the existing natural heritage system in the local landscape.

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 14/07/2009

**Direction:** NE

**Location:** NE Moyer Rd / Tintern Rd

**UTM:**

**Description:** View off of cliff top down into naturally regenerating pit

**11166_NE_photo 1.JPG**

---

**Taken By:** Heather Davis, Savanta

**Date of Photo:** 14/07/2009

**Direction:** N

**Location:** NE Moyer Rd / Tintern Rd

**UTM:**

**Description:** View north along west boundary of forest

**11166_N_photo 2.JPG**



## Legend

Licence Boundary

Date of Image: 10/07/2007
(After Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 79
Site 179

1:8,000

December 3, 2009

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SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap79_SAV179.mxd)
04/12/2009 -- 1:32:42 PM

# Task 2 Appendix A Site Summary

## Site: 180

**Geographical Township:** VAUGHAN

**Township or City:** VAUGHAN

**County or Region:** YORK R　　**Geographical Area:** ORM

**Pit or Quarry:** Pit　　**Surrender Date:** 19/01/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Possible recreation depending on municipal demand.

**Licenced Area:** 66.4　　**Area to be Extracted:** 60

**Existing Land Use:**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ | |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ | 100% |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ | |

Open space, no recreational use apparent.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration** ☐



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 80
Site 180

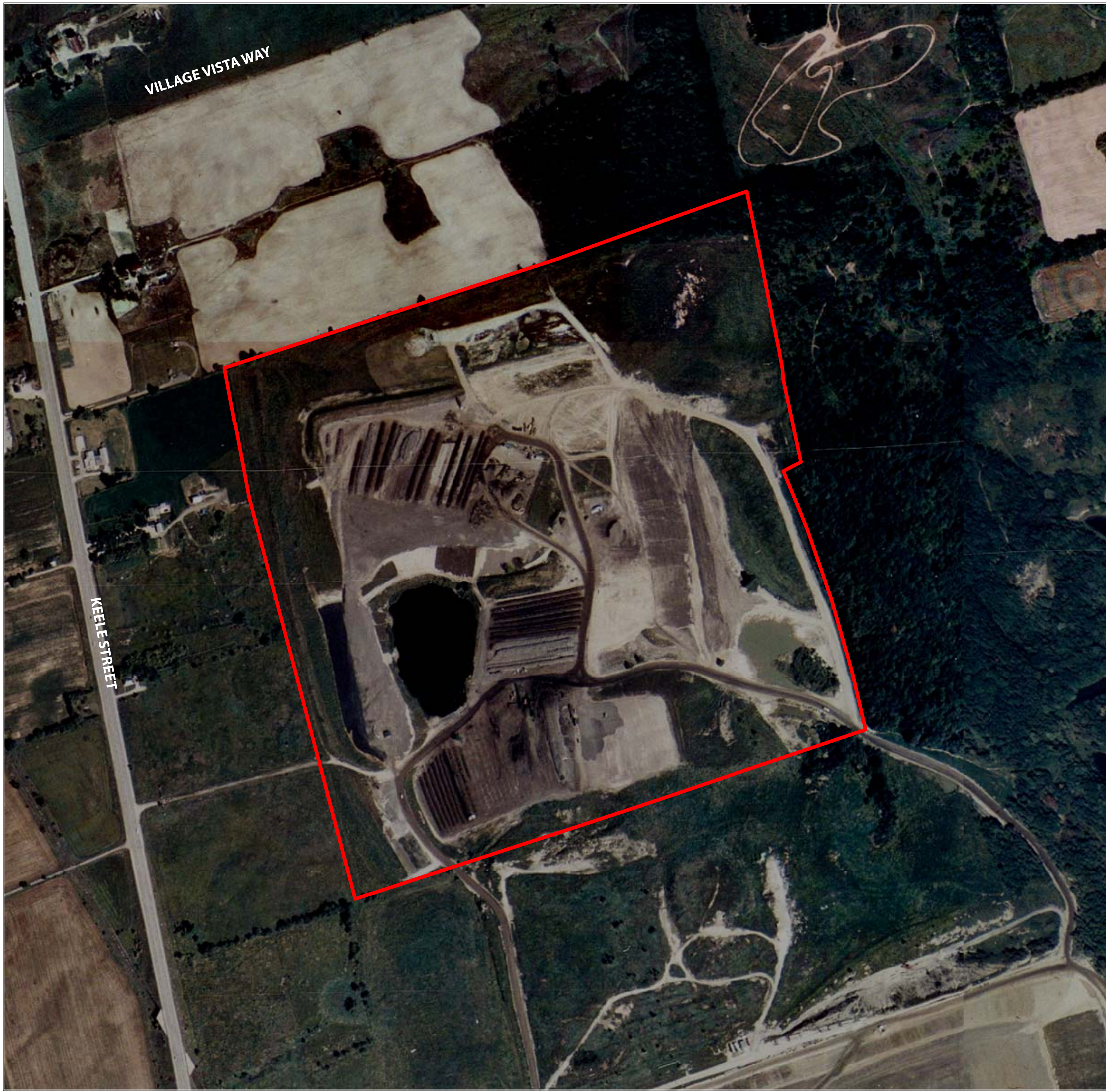
1:8,000

December 3, 2009

Skelton Brumwell & ASSOCIATES INC.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap80_SAV180.mxd)
04/12/2009 -- 1:35:46 PM





**Legend**

Licence Boundary

Date of Image: 1995
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 80b
Site 180

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap80_SAV180_1995.mxd)
04/12/2009 -- 1:48:20 PM

# Task 2 Appendix A Site Summary

## Site: 181

**Geographical Township:** EAST GWILLIMBURY

**Township or City:** EAST GWILLIMBURY TWP

**County or Region:** YORK REGION

**Geographical Area:** ORM

**Pit or Quarry:** Pit

**Surrender Date:** 22/10/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

- **Residential** ☐
- **Recreational** ☐
- **Commercial** ☐
- **Institutional** ☐
- **Industrial** ☐
- **Open Space** ☐
- **Natural** ☐
- **Agricultural** ☑
- **Other** ☐

**Licenced Area:** 21.23

**Area to be Extracted:** 15.15

**Existing Land Use:**

- **Residential** ☐
- **Recreational** ☐
- **Commercial** ☐
- **Institutional** ☐
- **Industrial** ☐
- **Open Space** ☑ 100%
- **Natural** ☐
- **Agricultural** ☐
- **Other** ☐

Open space - no visible signs of erosion.
Well vegatated - different vegetation on floor from slopes- could be transition to agriculture.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Good as open space or farm land

---

**Taken By:** Anne Guiot, SBA

**Date of Photo:** 06/08/2009

**Direction:** NE

**Location:** Mid-point of southern boundary

**UTM:**

**Description:** Northern slope can be seen with floor tying into agriculture to the east.

**6632_ STN 1 NE- Mid point south boundary.JPG**

---

**Taken By:** Anne Guiot, SBA

**Date of Photo:** 06/08/2009

**Direction:** North

**Location:** Centre of southern boundary

**UTM:**

**Description:** Perimter slopes visible with potential agriculture on floor.

**6632_STN 2 N- Centre South Boundary.JPG**



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 81
Site 181

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap81_SAV181.mxd)
04/12/2009 -- 1:50:36 PM

# Task 2 Appendix A Site Summary

## Site: 182

**Geographical Township:** GEORGINA

**Township or City:** GEORGINA

**County or Region:** YORK R **Geographical Area:** Greenbelt

**Pit or Quarry:** Pit **Surrender Date:** 14/05/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☑ | **Open Space** | ☐ |
| **Natural** | ☑ | **Agricultural** | ☑ | **Other** | ☐ |

Industrial uses include concrete, asphalt and construction yard.

**Licenced Area:** 123.75 **Area to be Extracted:** 34.1

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ 65% |
| **Natural** | ☑ 35% | **Agricultural** | ☐ | **Other** | ☐ |

Appears to have remained in a non-rehabilitated state as visible formerly excavated areas are either bare or sparsely and naturally revegetated. It appears the operation was limited to a few access routes, the remainder of the licence still in natural state.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Very well integrated as little excavation appears to have taken place.

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 13/07/2009

**Direction:** E

**Location:** from RRd 18

**UTM:**

**Description:** Telephoto vew of bare slopes in distance

**6637_photo1.JPG**

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 13/07/2009

**Direction:** E

**Location:** from RRd 18, just S of Hwy 48

**UTM:**

**Description:** stokpiles of topsoil

**6637_photo2.JPG**



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6
REHABILITATION
TASK 2 - SURRENDERED LICENCES**

FIGURE 82
Site 182

1:8,000

N W E S

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap82_SAV182.mxd)
04/12/2009 -- 1:57:15 PM



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 82b
Site 182

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap82_SAV182_2.mxd)
04/12/2009 -- 1:57:51 PM

# Task 2 Appendix A Site Summary

## Site: 182

**Geographical Township:** GEORGINA

**Township or City:** GEORGINA

**County or Region:** YORK R

**Geographical Area:** Greenbelt

**Pit or Quarry:** Pit

**Surrender Date:** 14/05/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☑ | **Open Space** | ☐ |
| **Natural** | ☑ | **Agricultural** | ☑ | **Other** | ☐ |

Industrial uses include concrete, asphalt and construction yard.

**Licenced Area:** 123.75

**Area to be Extracted:** 34.1

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ 65% |
| **Natural** | ☑ 35% | **Agricultural** | ☐ | **Other** | ☐ |

Appears to have remained in a non-rehabilitated state as visible formerly excavated areas are either bare or sparsely and naturally revegetated. It appears the operation was limited to a few access routes, the remainder of the licence still in natural state.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Very well integrated as little excavation appears to have taken place.

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 13/07/2009

**Direction:** E

**Location:** from RRd 18

**UTM:**

**Description:** Telephoto vew of bare slopes in distance

**6637_photo1.JPG**

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 13/07/2009

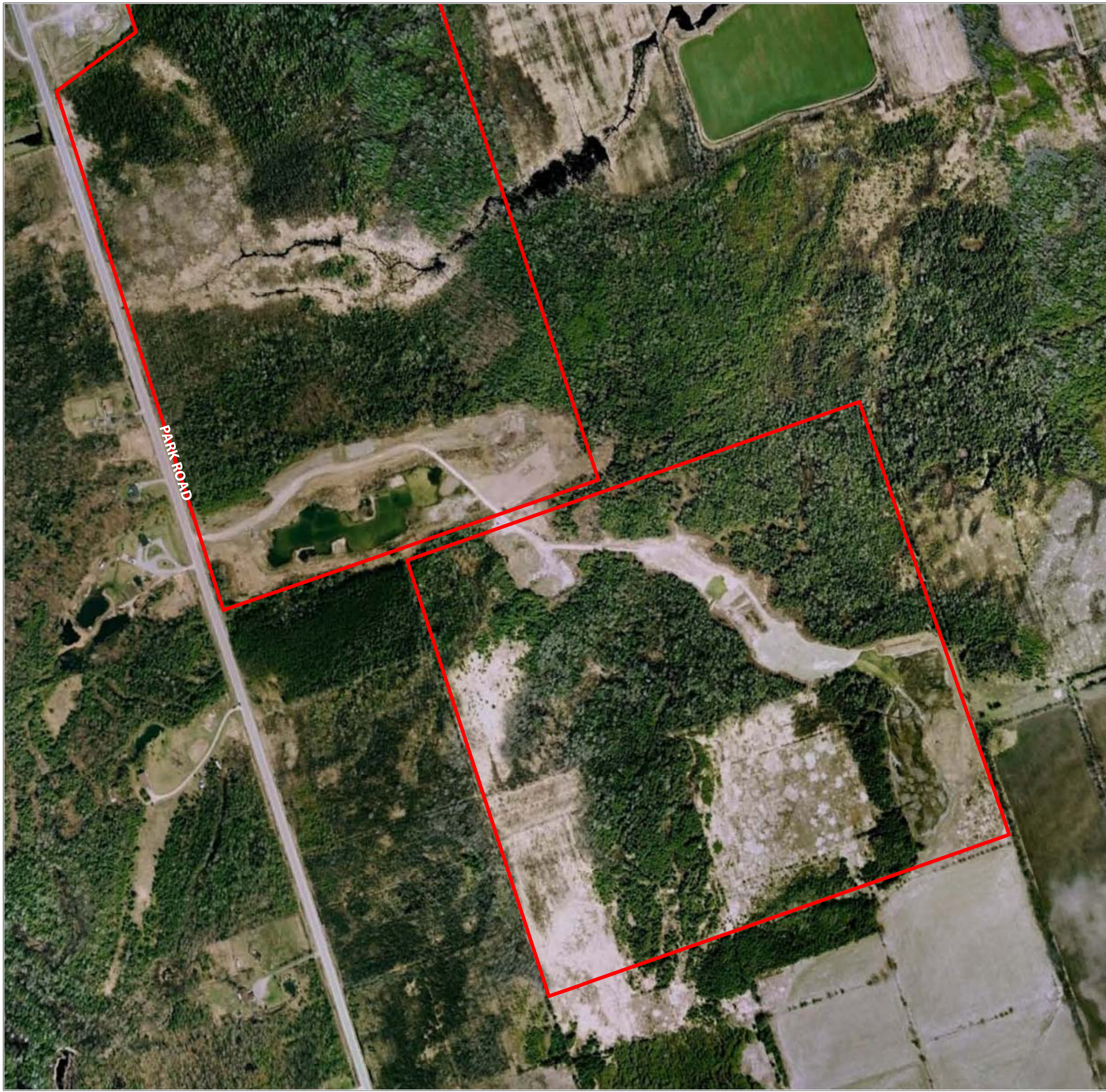
**Direction:** E

**Location:** from RRd 18, just S of Hwy 48

**UTM:**

**Description:** stokpiles of topsoil

**6637_photo2.JPG**





## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 82
Site 182

N W E S

1:8,000

December 3, 2009

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SAVANTA



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 82b
Site 182

1:8,000

N W E S

December 3, 2009

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SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap82_SAV182_2.mxd)
04/12/2009 -- 1:57:51 PM

# Task 2 Appendix A Site Summary

## Site: 183

**Geographical Township:** WHITCHURCH

**Township or City:** WHITCHURCH-STOUFFVILLE

**County or Region:** YORK R **Geographical Area:** ORM

**Pit or Quarry:** Pit **Surrender Date:** 03/01/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

**Licenced Area:** 58.3 **Area to be Extracted:** 51.91

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☑ 10% | **Agricultural** | ☑ 20% | **Other** | ☑ 70% |

Part of the site is being filled. There is obvious erosion around pond. Woodlot at east end of the site and agricultural lands in the south west appear undisturbed.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration** ☐ Not integrated, end land use not apparent.



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 83
Site 183

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap83_SAV183.mxd)
04/12/2009 -- 2:09:00 PM



## Legend

Licence Boundary

Date of Image: 1995
(Before Licence Surrender)

Imagery used with permission from Ontario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 83b
Site 183

1:8,000

N W E S

December 3, 2009

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SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap83_SAV183_1995.mxd)
04/12/2009 -- 2:10:11 PM

# Task 2 Appendix A Site Summary

## Site: 184

**Geographical Township:** UXBRIDGE

**Township or City:** UXBRIDGE TP

**County or Region:** DURHAM R **Geographical Area:** ORM

**Pit or Quarry:** Pit **Surrender Date:** 01/12/2005 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Recreational and/or residential with appropriate approvals.

**Licenced Area:** 147.8 **Area to be Extracted:** 113.4

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☑ 100% | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Beautifully rehabilitated to golf course.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ As much as a golf course can be.

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 11/08/2009

**Direction:** S

**Location:** From Hwy 47

**UTM:**

**Description:** General view of golf course

**6585_photo1.JPG**

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 11/08/2009

**Direction:** S

**Location:** From Hwy 47

**UTM:**

**Description:** Panoramic view of golf course

**6585_photo2.JPG**



**Legend**

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6
REHABILITATION
TASK 2 -
SURRENDERED LICENCES**

FIGURE 84
Site 184

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap84_SAV184.mxd)
04/12/2009 -- 2:20:11 PM

# Task 2 Appendix A Site Summary

## Site: 185

**Geographical Township:** STAMFORD

**Township or City:** NIAGARA FALLS

**County or Region:** NIAGARA R **Geographical Area:** NEC

**Pit or Quarry:** Quarry **Surrender Date:** 01/04/2008 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ | **Other** | ☐ |

**Licenced Area:** 59.2 **Area to be Extracted:** 44.6

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☑ 95% | **Open Space** | ☐ |
| **Natural** | ☑ 5% | **Agricultural** | ☐ | **Other** | ☐ |

Licenced area is now used as landfill. On the east side of Taylor Road a new pit has been started and no rehabilitation has taken place. To compensate for the habitat lost, Walker has restored a stretch of the 10 Mile Creek.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☐ It is the restored creek valley that is in balance with nature, not the other way around

---

**Taken By:** Chris Zoladeski, Savanta

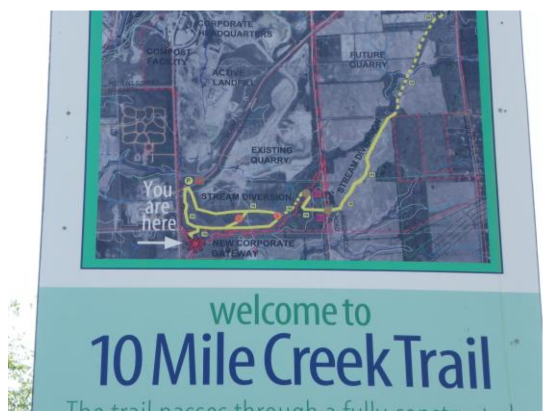
**Date of Photo:** 10/07/2009

**Direction:** Not applicable

**Location:**

**UTM:**

**Description:** Interpretive sign




**8336_photo1.JPG**

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 10/07/2009

**Direction:** Not applicable

**Location:**

**UTM:**

**Description:** Interpretive sign


**8336_photo2.JPG**

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 10/07/2009

**Direction:** E

**Location:** Along trail by the creek

**UTM:**

**Description:** Creek restoration, N bank

8336_photo3.JPG

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 10/07/2009

**Direction:** SW

**Location:** Along trail by the creek

**UTM:**

**Description:** Creek restoration, N bank

8336_photo4.JPG

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 10/07/2009

**Direction:** E

**Location:** From bridge

**UTM:**

**Description:** Creek valley, general view.

8336_photo5.JPG



**Legend**

Licence Boundary

Date of Image: 28/07/2007
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 85
Site 185

1:8,000

N W E S

December 3, 2009

Skelton Brumwell & ASSOCIATES INC.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap85_SAV185.mxd)
04/12/2009 -- 2:25:49 PM

# Task 2 Appendix A Site Summary

## Site: 186

**Geographical Township:** UXBRIDGE

**Township or City:** UXBRIDGE TP

**County or Region:** DURHAM R **Geographical Area:** ORM

**Pit or Quarry:** Pit **Surrender Date:** 09/11/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| Residential | ☐ | Recreational | ☐ | Commercial | ☐ |
| Institutional | ☐ | Industrial | ☐ | Open Space | ☑ |
| Natural | ☐ | Agricultural | ☐ | Other | ☐ |

**Licenced Area:** 9.62 **Area to be Extracted:** 8.37

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| Residential | ☐ | Recreational | ☐ | Commercial | ☐ |
| Institutional | ☐ | Industrial | ☐ | Open Space | ☑ 100% |
| Natural | ☐ | Agricultural | ☐ | Other | ☐ |

Old field meadow

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☐ Not well integraded, being on open concave area covered by forbs and grasses

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 11/08/2009

**Direction:** W

**Location:** From Lakeridge Road

**UTM:**

**Description:** General view

6590_photo1.JPG

---

**Taken By:** Chris Zoladeski, Savanta

**Date of Photo:** 11/08/2009

**Direction:** W

**Location:** From Lakeridge Road

**UTM:**

**Description:** General view

6590_photo2.JPG



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 86
Site 186

1:8,000

N W E S

December 3, 2009

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SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap86_SAV186.mxd)
04/12/2009 -- 2:31:20 PM

# Task 2 Appendix A Site Summary

## Site: 187

**Geographical Township:** BROCK

**Township or City:** BROCK TWP

**County or Region:** DURHAM REGION **Geographical Area:** Greenbelt

**Pit or Quarry:** Pit **Surrender Date:** 05/11/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ | **Other** | ☐ |

Pasture

**Licenced Area:** 6.63 **Area to be Extracted:** 3.76

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ 100% | **Other** | ☐ |

Agricultural

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration** ☑ Agricultural use in agricultural area.



## Legend

Licence Boundary

Date of Image: 2008
(After Licence Surrender)

Imagery used with permission from Ontario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 87
Site 187

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap87_SAV187.mxd)
04/12/2009 -- 2:35:45 PM



**Legend**

Licence Boundary

Date of Image: 2002
(Before Licence Surrender)

Imagery used with permission from Ontario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 87b
Site 187

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap87_SAV187_2002.mxd)
04/12/2009 -- 3:01:11 PM

# Task 2 Appendix A Site Summary

## Site: 188

**Geographical Township:** WHITBY

**Township or City:** WHITBY

**County or Region:** DURHAM R

**Geographical Area:** Greenbelt

**Pit or Quarry:** Pit

**Surrender Date:** 03/06/2009 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Topsoil to be replaced and seeded (Site Plan).

**Licenced Area:** 19.39

**Area to be Extracted:** 10.8

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ 100% |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

From MNR Licence profile: "No further aggregate extraction is occuring on this site. All faces have been sloped and are green. Pit floor is mostly vegetated." Rehabilitated land.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Adjacent land uses are mainly forested, however rehabilitated area is integrated with old fields to the west.

---

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** N

**Location:**

**UTM:**

**Description:**

**3182_Photo1_N.jpg**

---

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** N

**Location:**

**UTM:**

**Description:**

**3182_Photo2_N.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** E

**Location:**

**UTM:**

**Description:**

**3182_Photo3_E.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** W

**Location:**

**UTM:**

**Description:**

**3182_Photo4_W.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** S

**Location:**

**UTM:**

**Description:**

**3182_Photo5_S.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** W

**Location:**

**UTM:**

**Description:**

**3182_Photo6_W.jpg**



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

Imagery used with permission from Ontario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 88
Site 188

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap88_SAV188.mxd)
04/12/2009 -- 3:09:00 PM

# Task 2 Appendix A Site Summary

## Site: 189

**Geographical Township:** HARVEY

**Township or City:** GALWAY-CAVENDISH AND HARVEY TWP

**County or Region:** PETERBOROUGH COUNTY **Geographical Area:** East

**Pit or Quarry:** Quarry **Surrender Date:** 17/09/2002 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Unspecified

**Licenced Area:** 4.86 **Area to be Extracted:** 3.24

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ 100% |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Former quarry area still visible on Air Photo. Use of the site not apparent.

**Adjacent Land Uses:** Remote

**Adjacent Land Use Integration** ☐ Opening in forested area. Not visible from public roads.


## Legend

Licence Boundary

Date of Image: 2008
(After Licence Surrender)

Imagery used with permission from Ontario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 89
Site 189

N
W E
S

1:8,000

December 3, 2009

Skelton Brumwell & ASSOCIATES INC.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap89_SAV189.mxd)
04/12/2009 -- 3:21:39 PM

# Task 2 Appendix A Site Summary

## Site: 190

**Geographical Township:** MARMORA

**Township or City:** MUNICIPALITY OF MARMORA AND LAKE

**County or Region:** HASTINGS COUNTY **Geographical Area:** East

**Pit or Quarry:** Quarry **Surrender Date:** 22/10/1998 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☑ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Old Quarry is a swimming hole - community swimming and picnic area. (Site Plan)

**Licenced Area:** 40 **Area to be Extracted:** 5

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☑ 100% | **Agricultural** | ☐ | **Other** | ☐ |

Natural - based on Air Photo. Recreational use identified in Site Plan Notes, could not be verified.

**Adjacent Land Uses:** Remote

**Adjacent Land Use Integration** ☑ Ponds created by quarry use not distinguishable from natural ponds etc. in vicinity.(Air Photo)



## Legend

Licence Boundary

Date of Image: 27/05/2006
(After Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 90
Site 190

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap90_SAV190.mxd)
04/12/2009 -- 5:54:24 PM

# Task 2 Appendix A Site Summary

## Site: 191

**Geographical Township:** CLARKE

**Township or City:** CLARINGTON

**County or Region:** DURHAM R

**Geographical Area:** Greenbelt

**Pit or Quarry:** Pit

**Surrender Date:** 26/06/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☑ | **Other** | ☐ |

**Licenced Area:** 38.69

**Area to be Extracted:** 20.27

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ 100% |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Rehabilitated aggregate pit.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Integrated with other old fields located to the west of Morgan Road, in locations 'C' and 'D'.

---

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** E

**Location:**

**UTM:**

**Description:**

**3201_Photo1_E.jpg**

---

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** E

**Location:**

**UTM:**

**Description:**

**3201_Photo2_E.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** W

**Location:**

**UTM:**

**Description:**

**3201_Photo3_W.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** W

**Location:**

**UTM:**

**Description:**

**3201_Photo4_W.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** E

**Location:**

**UTM:**

**Description:**

**3201_Photo5_E.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** E

**Location:**

**UTM:**

**Description:**

**3201_Photo6_E.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** N

**Location:**

**UTM:**

**Description:**

**3201_Photo7_N.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** S

**Location:**

**UTM:**

**Description:**

**3201_Photo8_S.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** W

**Location:**

**UTM:**

**Description:**

**3201_Photo9_W.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** E

**Location:**

**UTM:**

**Description:**

**3201_Photo10_E.jpg**

**Taken By:** George Buckton, Savanta

**Date of Photo:** 06/08/2009

**Direction:** N

**Location:**

**UTM:**

**Description:**

3201_Photo11_N.jpg



## Legend

Licence Boundary

Date of Image: 05/03/2005
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 91
Site 191

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap91_SAV191.mxd)
04/12/2009 -- 5:59:15 PM

# Task 2 Appendix A Site Summary

## Site: 192

**Geographical Township:** KINGSTON

**Township or City:** CITY OF KINGSTON

**County or Region:** FRONTENAC COUNTY **Geographical Area:** East

**Pit or Quarry:** Quarry **Surrender Date:** 30/11/2004 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☑ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☐ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Park (Site Plan)

**Licenced Area:** 12.2 **Area to be Extracted:** 8.6

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ 100% |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Open space, not other land use apparent - based on 2004 Air Photo>

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration** ☐ Opening adjacent to meadow and woodland.



## Legend

Licence Boundary

Date of Image: 2008
(After Licence Surrender)

Imagery used with permission from Ontario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 92
Site 192

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap92_SAV192.mxd)
04/12/2009 -- 6:14:19 PM

# Task 2 Appendix A Site Summary

## Site: 193

**Geographical Township:** KINGSTON

**Township or City:** CITY OF KINGSTON

**County or Region:** FRONTENAC COUNTY **Geographical Area:** East

**Pit or Quarry:** Quarry **Surrender Date:** 31/12/2001 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Not specified

**Licenced Area:** 12.14 **Area to be Extracted:** 10

**Existing Land Use:**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Residential** | ☐ | | **Recreational** | ☐ | | **Commercial** | ☑ | 50% |
| **Institutional** | ☑ | 10% | **Industrial** | ☑ | 20% | **Open Space** | ☑ | 20% |
| **Natural** | ☐ | | **Agricultural** | ☐ | | **Other** | ☐ | |

Gas Station, Restaurant, Parking Area

**Adjacent Land Uses:** Urban

**Adjacent Land Use Integration:** ☑ Residential/Commercial.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 06/08/2009

**Direction:** Northwest

**Location:** STN 1- Edge of stormwater pond off Robinson Court

**UTM:**

**Description:** Stormwater pond with access roadway off Robinson Court. North is Highway 401E, south is gas station.

**2910_STN 1 NW- Stormwater Pond.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 06/08/2009

**Direction:** Northeast

**Location:** Robinson Court

**UTM:**

**Description:** Looking northeast along Robinson Court towards motel (under construction) in northwest corner of the licence.

**2910_STN 1- NE- Muncipal road to motel.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 06/08/2009

**Direction:** North

**Location:** Corner of Robinson Court and Centennial Road

**UTM:**

**Description:** Looking north from intersection. To the east (right), Canada Government building can be seen.

**2910_ STN 2 N- Muncipal Road.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 06/08/2009

**Direction:** Northwest

**Location:** Corner of Centennial Road and Robinson Court

**UTM:**

**Description:** Looking northwest to gas station in southwest corner of the licence.


**2910 STN 2 NW- Gas Station.JPG**



## Legend

Licence Boundary

Date of Image: 30/07/2005
(After Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 93
Site 193

N W E S

1:8,000

December 3, 2009

Skelton Brumwell & ASSOCIATES INC.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap93_SAV193.mxd)
04/12/2009 -- 6:20:48 PM

# Task 2 Appendix A Site Summary

# Site: 194

**Geographical Township:** RAMSAY

**Township or City:** TOWN OF MISSISSIPPI MILLS

**County or Region:** LANARK COUNTY

**Geographical Area:** East

**Pit or Quarry:** Quarry

**Surrender Date:** 18/06/2004 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

- **Residential** ☑
- **Recreational** ☐
- **Commercial** ☐
- **Institutional** ☐
- **Industrial** ☐
- **Open Space** ☐
- **Natural** ☐
- **Agricultural** ☐
- **Other** ☐

**Licenced Area:** 1.5

**Area to be Extracted:** 1.2

**Existing Land Use:**

- **Residential** ☑ 100%
- **Recreational** ☐
- **Commercial** ☐
- **Institutional** ☐
- **Industrial** ☐
- **Open Space** ☐
- **Natural** ☐
- **Agricultural** ☐
- **Other** ☐

Vacant, road and water servicing installed.

**Adjacent Land Uses:** Urban

**Adjacent Land Use Integration:** ☑ Integrating future residential development with adjacent residential community.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 05/08/2009

**Direction:** North

**Location:** Entrance to site from Adelaide Street

**UTM:**

**Description:** Entrance to licenced area from Adelaide Street. Appears to be currently under construction.

**4240_STN 1 N- entrance.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 05/08/2009

**Direction:** Northeast

**Location:** Entrance to site from Adelaide Street.

**UTM:**

**Description:** Looking northwest into site. Has been cleared and some services (water, sewer) for future residential development installed.

**4240_STN 2 N- northeast into site.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 05/08/2009

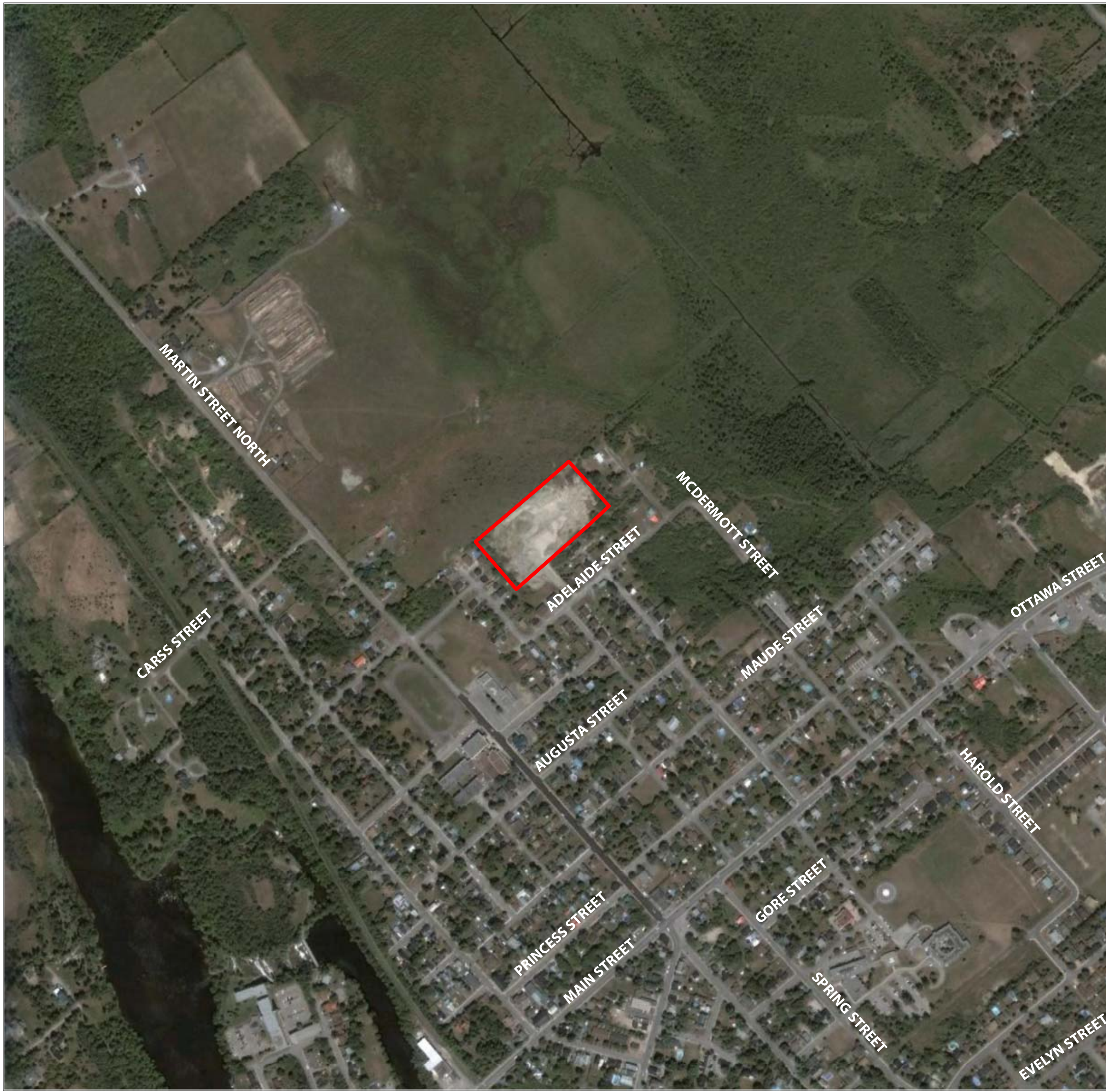
**Direction:** Northwest

**Location:** Entrance to site from Adelaide Street.

**UTM:**

**Description:** Looking northwest into the site. Tree screens visible in background between the site and adjacent residences.

**4240_STN 2 NW- west part of site.JPG**





## Legend

Licence Boundary

Date of Image: 25/07/2005
(After Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 94
Site 194

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap94_SAV194.mxd)
04/12/2009 -- 6:48:12 PM

# Task 2 Appendix A Site Summary

## Site: 195

**Geographical Township:** TORBOLTON

**Township or City:** OTTAWA

**County or Region:** OTTAWA-CARLETON R **Geographical Area:** East

**Pit or Quarry:** Quarry **Surrender Date:** 20/10/2004 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Pond with naturalized edges.

**Licenced Area:** 6.5 **Area to be Extracted:** 5.8

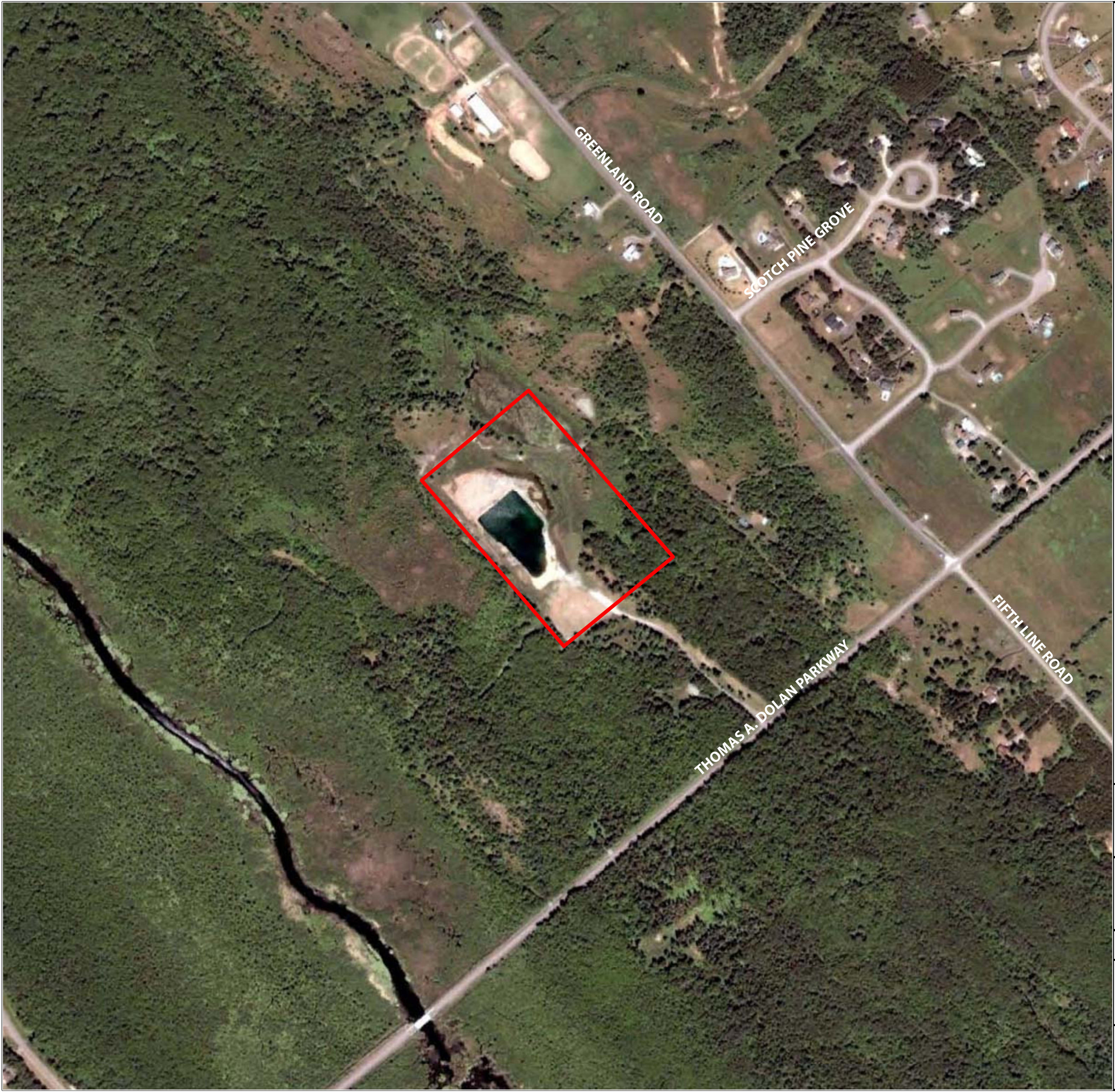
**Existing Land Use:**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ | |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ | 100% |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ | |

Open Space with pond based on 2006 air photo. Pond edges are angular.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration** ☑ Integrated with adjacent woodland and wetland.





**Legend**

Licence Boundary

Date of Image: 07/07/2005
(After Licence Surrender)

Imagery used with permission from Google Earth © 2009.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 95
Site 195

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap95_SAV195.mxd)
04/12/2009 -- 6:52:43 PM

# Task 2 Appendix A Site Summary

## Site: 196

**Geographical Township:** GLOUCESTER

**Township or City:** CITY OF OTTAWA

**County or Region:** OTTAWA-CARLETON REGION **Geographical Area:** East

**Pit or Quarry:** Pit **Surrender Date:** 20/12/2006 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☑ |

Site plan is illegible

**Licenced Area:** 10.5 **Area to be Extracted:** 6.7

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ 100% |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Industrial - school bus depot (2008 Photo), NCI Ontario Inc. sign on property.

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☐ Land use not integrated with adjacent features.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 05/08/2009

**Direction:** South

**Location:** Falcon Ridge Golf Course- edge of parking area

**UTM:**

**Description:** Golf putting area and driving range at Falcon Ridge Golf Course. Ths part of the Course is within an area that was deleted from the licence in 2002.

**4060_STN 1- Golf course.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 05/08/2009

**Direction:** South

**Location:** Edge of parking area and 1st hole

**UTM:**

**Description:** Looking south down the fairway of the 1st hole. Rement scrub vegetation can be seen to the east (right part of photo).

**4060_STN 1 S- fairway of golf course.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 05/08/2009

**Direction:** South

**Location:** Entrance to east part of pit from High Road.

**UTM:**

**Description:** Looking south into east part of licence. Cleared area where scale house was located.

**4060_STN 2 S- location of scale house.JPG**



## Legend

Licence Boundary

Date of Image: 05/08/2007
(After Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 96
Site 196

N W E S

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

# Task 2 Appendix A Site Summary

## Site: 197

**Geographical Township:** LOCHIEL

**Township or City:** NORTH GLENGARRY TWP

**County or Region:** STORMONT, DUNDAS AND GLENGARRY COUNTY **Geographical Area:** East

**Pit or Quarry:** Pit **Surrender Date:** 31/12/2005 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

- Residential ☐
- Recreational ☐
- Commercial ☐
- Institutional ☐
- Industrial ☐
- Open Space ☐
- Natural ☐
- Agricultural ☐
- Other ☑

Not shown or illegible

**Licenced Area:** 59.8 **Area to be Extracted:** 27.65

**Existing Land Use:**

- Residential ☐
- Recreational ☐
- Commercial ☐
- Institutional ☐
- Industrial ☐
- Open Space ☐
- Natural ☐
- Agricultural ☑ 100%
- Other ☐

Agriculture based on Air Photo

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ No indication of a pit from the road.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 06/08/2009

**Direction:** Northwest

**Location:** 50m east of entrance on Lochiel Road

**UTM:**

**Description:** Former entrance to the site. Residence on property can be seen in background.

5996_STN 1 NW- Entrance and existing residence..JPG

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 06/08/2009

**Direction:** North

**Location:** 50m west of entrance on Lochiel Road

**UTM:**

**Description:** Front area of property.

5996_STN 1 N- Front (Southern) part of site.JPG


## Legend

Licence Boundary

Date of Image: 07/05/2007
(After Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 97
Site 197

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap97_SAV197.mxd)
04/12/2009 -- 7:03:36 PM

# Task 2 Appendix A Site Summary

## Site: 198

**Geographical Township:** OSNABRUCK

**Township or City:** SOUTH STORMONT TWP

**County or Region:** STORMONT, DUNDAS AND GLENGARRY COUNTY **Geographical Area:** East

**Pit or Quarry:** Pit **Surrender Date:** 31/12/2008 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☑ |
| **Natural** | ☐ | **Agricultural** | ☐ | **Other** | ☐ |

Grassed slopes and unspecified tree Plantation (Site Plan)

**Licenced Area:** 13.2 **Area to be Extracted:** 10.9

**Existing Land Use:**

| | | | | | |
|---|---|---|---|---|---|
| **Residential** | ☐ | **Recreational** | ☐ | **Commercial** | ☐ |
| **Institutional** | ☐ | **Industrial** | ☐ | **Open Space** | ☐ |
| **Natural** | ☑ 85% | **Agricultural** | ☑ 15% | **Other** | ☐ |

Natural and agricultural. Based on Air Photo

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration** ☐ Unknown



## Legend

Licence Boundary

Date of Image: 16/06/2004
(Before Licence Surrender)

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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 98
Site 198

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap98_SAV198.mxd)
04/12/2009 -- 7:09:09 PM

# Task 2 Appendix A Site Summary

## Site: 199

**Geographical Township:** KENYON

**Township or City:** NORTH GLENGARRY TWP

**County or Region:** STORMONT, DUNDAS AND GLENGARRY COUNTY **Geographical Area:** East

**Pit or Quarry:** Pit **Surrender Date:** 15/06/2007 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Unknown

**Licenced Area:** 48 **Area to be Extracted:** 43

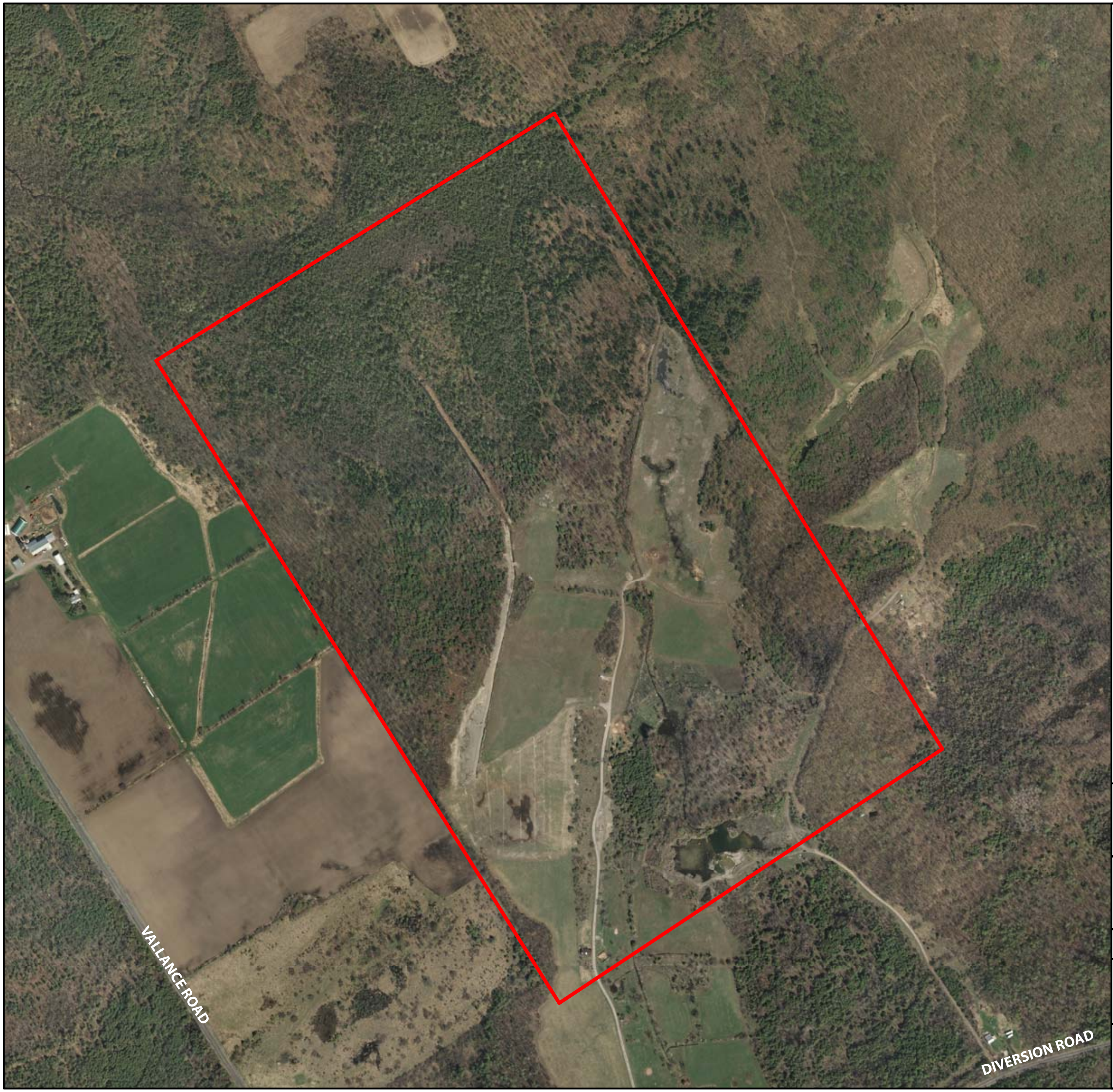
**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☐ |
| **Natural** ☐ | **Agricultural** ☑ 100% | **Other** ☐ |

Residential at entrance road. Based on air photo

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration** ☐ None





## Legend

Licence Boundary

Date of Image: 2008
(After Licence Surrender)

Imagery used with permission from Ontario Ministry of Natural Resources.
Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 99
Site 199

1:8,000

December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

Map Document: (D:\PROJECTS\SAROS\mxd\Site Maps\03dec09_sitemaps\SAROS_sitemap99_SAV199.mxd)
04/12/2009 -- 7:12:35 PM

# Task 2 Appendix A Site Summary

## Site: 200

**Geographical Township:** KENYON

**Township or City:** NORTH GLENGARRY TWP

**County or Region:** STORMONT, DUNDAS AND GLENGARRY COUNTY **Geographical Area:** East

**Pit or Quarry:** Pit **Surrender Date:** 31/12/2008 **(dd/mm/yyyy)**

**Proposed Final Rehabilitation Land Use:**

| | | |
|---|---|---|
| **Residential** ☐ | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Site Plan indicates grading and seeding only.

**Licenced Area:** 22.66 **Area to be Extracted:** 19.2

**Existing Land Use:**

| | | |
|---|---|---|
| **Residential** ☑ 5% | **Recreational** ☐ | **Commercial** ☐ |
| **Institutional** ☐ | **Industrial** ☐ | **Open Space** ☑ 95% |
| **Natural** ☐ | **Agricultural** ☐ | **Other** ☐ |

Residential, open space

**Adjacent Land Uses:** Rural

**Adjacent Land Use Integration:** ☑ Naturalized rolling grassland (visible). Some integration with surrounding landscape.

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 06/08/2009

**Direction:** South

**Location:** Entrance to property on Kenyon Concession 5 Road

**UTM:**

**Description:** Entrance to property from Kenyon Concession 5 Road. Rural residential property now present.

**5938_STN 1 SE- Entrance to property.JPG**

---

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 06/08/2009

**Direction:** Southeast

**Location:** Entrance to property on Kenyon Concession 5 Road

**UTM:**

**Description:** Buildings off rural residential property on the site. Slope of previous pit can be seen in background.

**5938_STN 1 S- Existing buildings fronting at edge of site.JPG**

**Taken By:** Kyle Fleming, SBA

**Date of Photo:** 06/08/2009

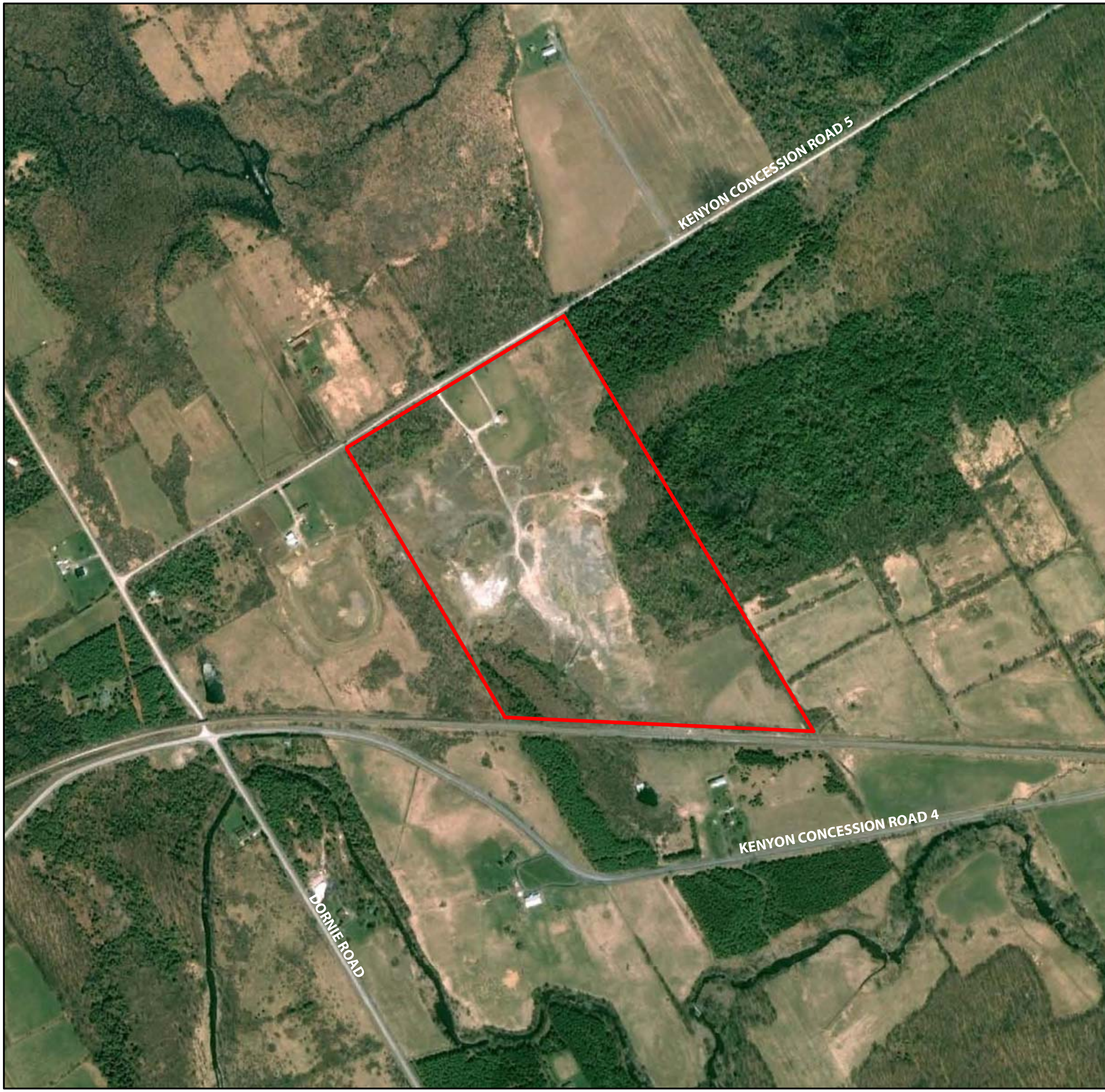
**Direction:** South

**Location:** 100 metres east of property entrance on Kenyon Concession 5 Ro

**UTM:**

**Description:** Looking at east edge of pit slope south of residential area now on property.

**5938_STN 2 S- Grassed slope to site.JPG**





## Legend

Licence Boundary

Date of Image: 07/05/2007
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Base mapping from Ontario Ministry of Natural Resources.

**SAROS PAPER 6**
**REHABILITATION**
**TASK 2 - SURRENDERED LICENCES**

FIGURE 100
Site 200
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December 3, 2009

Skelton Brumwell & Associates Inc.

SAVANTA

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# CHAPTER 6

# SAROS PAPER 6 REHABILITATION

# CURRENT SCIENCE AND METHODOLOGY

# FOR PIT AND QUARRY REHABILITATION

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# 1.0 INTRODUCTION

There is a significant amount of information available on rehabilitation outlining current science and specific methodologies for pit and quarry rehabilitation. This chapter delves into current science, and addresses the differences between pit and quarry rehabilitation.

Specifically this chapter will: "*Review current science recommendations for pit and quarry rehabilitation in Ontario and how they could support other initiatives such as the Biodiversity Strategy, Greenbelt Plan, Niagara Escarpment Plan, Source Water Protection and prime agricultural protection;*" and, "*Compare and contrast the difference in rehabilitation methodologies for quarries vs. pits. What works, what doesn't work. Discuss the factors affecting the application of progressive rehabilitation methodology for pits and quarries.*"

# 2.0 BACKGROUND

In the 1970s many pits and quarries in Ontario were rehabilitated to end land uses that tended to have a greater focus on "active" uses such as parks, recreational areas, golf courses, conservation land (with an emphasis on creating habitat for sport fish, furbearers and game species), and residential and commercial uses (Yundt 2009). In the 1980s, there was a shift to the inclusion of rehabilitation to agricultural lands. From the 1990s to the present, rehabilitation has tended to include a combination of both agricultural and natural heritage uses and new and specialized ecological restoration has begun to emerge in site plans (e.g., talus slope, fen and alvar rehabilitation).

There are a number of consistent and durable science based rehabilitation principles and practices documented within earlier publications. (MNR 1984; Yundt 2009; Mackintosh and Mozuraius 1982; Hilditch et al 1988; Michalski et al 1987; Yundt et al 1992; Lowe 1979; Miller and Mackintosh 1987; Mackintosh et al 1985; TOARC 2008). Rather than listing these aspects, this report provides an overview of the general approaches to the rehabilitation of pits and quarries in the context of current and emerging science recommendations and how they might contribute to advancing relevant provincial policies/legislations and priorities. Furthermore, comparisons are offered in this report relative to the different methodologies for pit and quarry rehabilitation, factors affecting these methodologies and to analyze the general success and failures of these examples.

The approach to Tasks 6 and 7 included seeking input from individuals who work in the field of rehabilitation and/or pit and quarry operations in two ways: (1) through the establishment of a Scientific Review Panel with representatives from MNR, academia, and non-government organizations (NGOs); and (2) contacting specific representatives from MNR, industry, consulting and the Management of Abandoned Aggregate Properties (MAAP) program as part of the research related to better understanding the different methodologies for pit and quarry rehabilitation. This information was further supplemented from international examples and contacts, and presented in summary fashion in this chapter.

## 2.1 Workshop: SAROS Scientific Review Panel

In order to gain a more fulsome perspective regarding the current scientific recommendations related to the rehabilitation of pits and quarries in Ontario, and also to draw from broader principles related to restoration ecology, a workshop was held in Mississauga, Ontario on October 14th, 2009. Attendees at the workshop are listed in Appendix A and were selected from a wide range of disciplines and affiliations in order to maximize the potential for a comprehensive exchange of ideas. The entire workshop was filmed in order to document the discussion and for possible use as an educational tool related to the SAROS initiative, and summary notes emerging from the notes can be found in Appendix A.

Summary data derived from both Task 1 and 2 sites were presented to the Scientific Review Panel in the context of current recommendations related to the rehabilitation of pits and quarries in Ontario. Several specific case studies drawn from the Task 1 and 2 sites were highlighted in order to further elucidate the latter but also to highlight the extent to which these sites can and do contribute to selected provincial policies and legislations. Out of this summary emerged specific knowledge gaps (Section 5.0) related to the current science recommendations and opportunities for improving on the approaches to the rehabilitation of pits and quarries in order to better meet broader provincial socio-economic and ecological objectives. This formed the basis for a discussion at the workshop, excerpts of which are summarized below, and set the stage for specific recommendations emerging out of this Chapter.

# 3.0 CURRENT SCIENCE RECOMMENDATIONS

While there are a number of key differences in the approaches to the rehabilitation of pits and quarries, there are also fundamentals that are transferable between the two. Section 3.1 sets out general recommendations that are applicable to the rehabilitation of both pits and quarries, while the remainder of Section 3 outlines approaches that are unique to either pits or quarries.

## 3.1 Rehabilitation of Pits and Quarries: Commonalities

### 3.1.1 Pre-Planning

Pre-planning is consistently emphasized as a critical need to ensure successful rehabilitation of pits and quarries (MNR 1984; Yundt 2009; Mackintosh and Mozuraitus 1982; Hilditch et al 1988; Michalski et al 1987; TOARC 2008). Early compilation of baseline information should include consideration of topsoil, subsoil and overburden characteristics such as organic matter, stoniness, structure, texture, soil capability, crop yields, depth of extraction, elevation of water table, surface water drainage patterns, surface water quality for water bodies on or adjacent to the site, geology of the site, and floral and faunal characteristics. Associated with the pre-planning stage is a need to a gain an understanding of past and present land uses, including the types of crops and/or natural habitat features occurring pre-extraction, relief or topography of the area, and how the post-extraction topography will affect the end land use terrain conditions (i.e. drainage, slope, presence of exposed bedrock, prevailing micro-climatic conditions, etc).

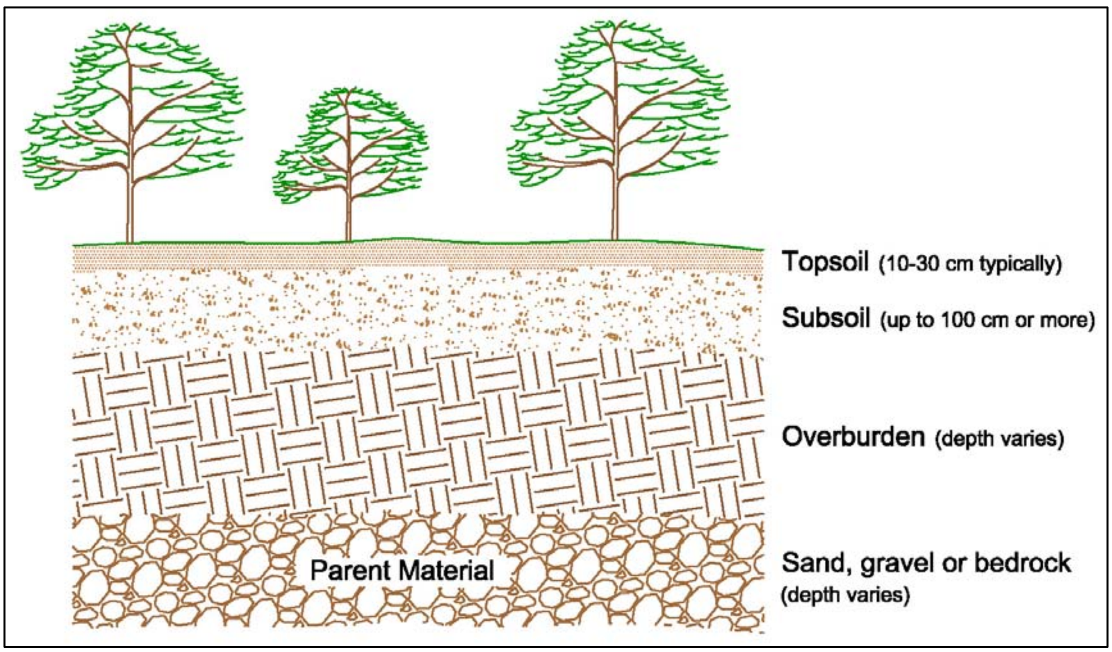
Consideration of the biophysical characteristics of the pit or quarry and the surrounding land uses from the outset will improve the probability that the site will successfully integrate into the surrounding landscape in its rehabilitated state. In theory, the site plans should capture this information by outlining existing features, detailing the operational plan, and establishing requirements for the rehabilitation plan. In some cases, specific information about immediately adjacent lands will contribute to an understanding of where natural succession will be moving (e.g., influence of potential, adjacent seed rain sources).

### 3.1.2 Stripping and Stockpiling

A soil strategy is highly recommended as part of the pre-planning stage in order to develop a planned program for the movement of soil materials, outlining how and where they will be stored and how, when, and where they will be replaced (UK Ministry of Agriculture, Fisheries and Food 2000). Efforts to minimize double handling of soils will not only reduce costs but also damage to the soils. Ideally, stripped soil materials are placed directly into areas under rehabilitation; however, due to economies of scale, stripping does not always occur every year on every site. In other words, the amount of potential annual rehabilitation is often directly associated with the amount of stripping carried out that year.

There are three distinct layers of soil: topsoil; subsoil; and the overburden (see Figure 1). Topsoil is recognized as the darker colour associated with the accumulation of organic matter, and on arable lands is typically restricted to the uppermost 15-30 cm. A key component of topsoil is the organic matter since it promotes the development of good soil structure and soil strength. These are critical characteristics to withstand mechanical pressures from agricultural machinery in the case of this end use, and organic matter also improves water holding capacity and supplies nutrients for plant growth (Mackintosh and Mozuraitus 1982).

**Figure 1 – Cross Section of Soil Substrate**




The subsoil is the zone located immediately beneath the topsoil and may extend to a depth of 1 metre or more. The subsoil readily compacts causing a reduction in water movement and root penetration and this will reduce the volume of soil available for plant growth, thereby affecting overall yields. Overburden is all the material lying between the subsoil and the workable sand

and gravel deposits and varies in its suitability for agronomic purposes, although the quality varies from one site to another (Mackintosh and Mozuraitus 1982).

Topsoil should be stripped under dry conditions to minimize compaction. It should be stored separately from the subsoil and overburden, so that it can be returned to the site uncontaminated by the less fertile layers of the soil. The topsoil should be reinstated as soon as possible to reduce the loss of structure and nutrient value and microbial activity associated with stockpiling, and also to avoid handling more than once (Hilditch et al 1988; TOARC 2008). Mackintosh and Mozuraitus (1982) suggest that, as a general rule, topsoil should not be stored more than about 5 years, while others state that after as little as one year, structural and chemical deterioration of the soil composition may occur (Goodquarry 2009). Ideally, once required berms are in place, stripped topsoil and overburden should be utilized in progressive rehabilitation.

A review of the Task 1 sampling of sites suggests that the topsoil is generally stockpiled separately from the subsoil and overburden, consistent with best practices recommendations and Provincial Standards requirements. However, the soil materials were found to be stored anywhere from 0 to over 30 years, with the lower range including those soils that are moved immediately to areas where progressive rehabilitation is being undertaken with little to no stockpiling or double handling. Soils stockpiled longer tend to be piled in berms for use in noise attenuation or for visual screening that is generally required for the life of the pit.

### 3.1.3 Slopes and Cliff Faces

Rehabilitated slopes are to be no steeper than 2:1 (quarries) or 3:1 (pits) as directed by the Provincial Standards of the Aggregate Resources Act (ARA). Slopes of 3:1 or gentler will allow for rehabilitation with trees and shrubs, while steeper slopes are better limited to the use of grasses (Darrin Johnson, pers. comm., September 24th 2009). There are three types of created slopes: (1) cut and fill slopes; (2) backfilled slopes; and (3) In-situ slopes (Figure 2). Cut slopes result from the extraction of gravel and rock in that local materials are used to create the slope, while fill slopes are associated with 100% backfilling

When using the cut and fill methodology, excavation must not reach the limit of extraction, but stop in advance, so the remaining material between the face and the limit of extraction can be used to create the slope. This approach might be used in cases where:

- Poorer quality material exists around the perimeter and it is more cost effective to use in-place material than hauling overburden or lower grade product from another location within the pit or quarry; and/or

- There is insufficient backfill material available elsewhere on the site; or

- The operator is unable to, or uninterested in bringing in fill material from off-site.

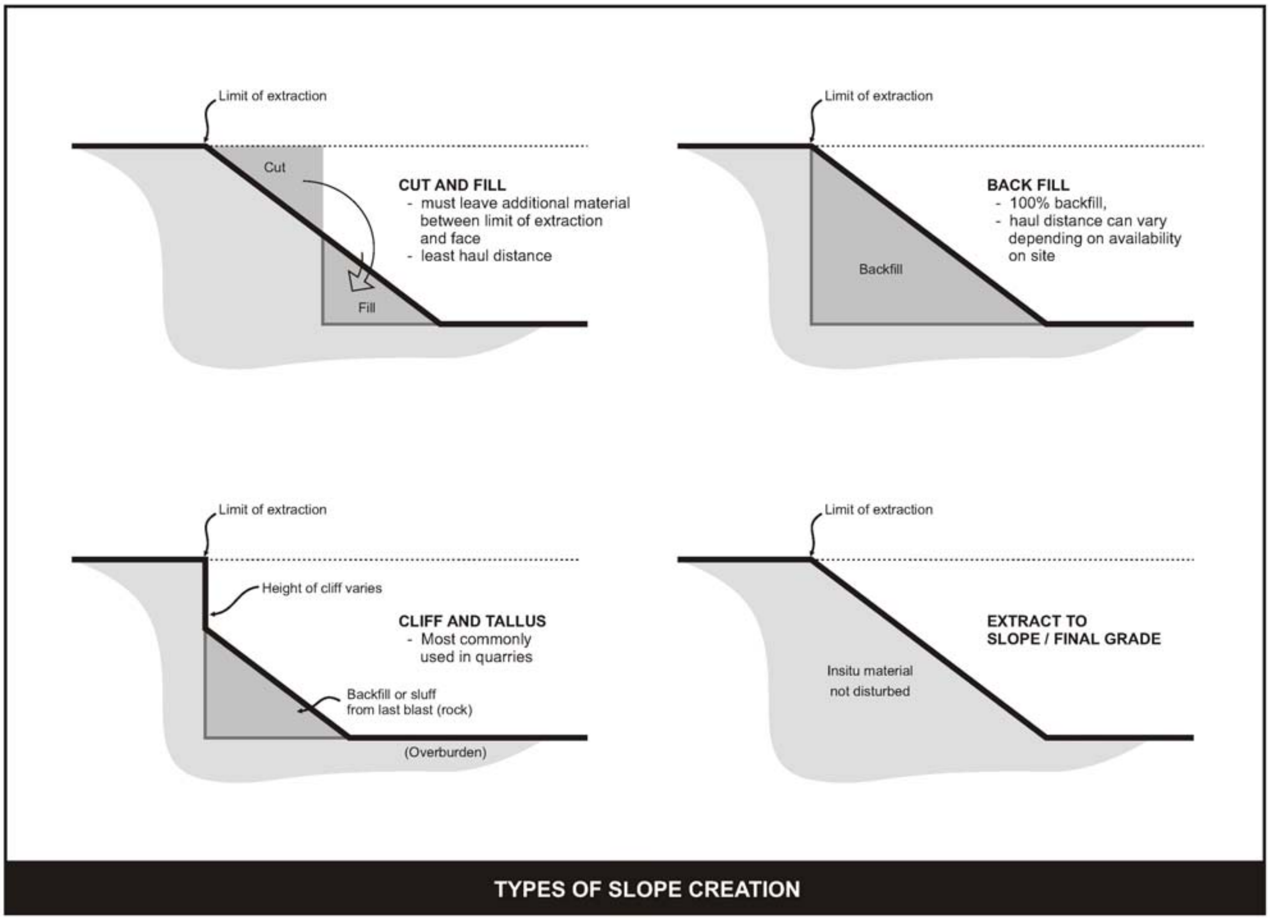
Backfilling enables extraction to the limit of the footprint and then material is brought in to create the slope. This example would be used where;

- The quality of the material warrants extraction to the limit of extraction; and

- There is enough material on site of sufficient quality (e.g. clay is not suitable in most cases) to backfill to the required grade; and/or

- The operator is able to, or interested in bringing fill material from off-site.

**Figure 2 – Type of Slope Creation**




In some pits, extraction may occur to the final grade, leaving the whole slope with in-situ material. This method is advantageous with lower quality material thereby reducing the cost of material movement and slope creation.

In all cases it is advantageous to rip the soils on the slope (and floor, where applicable) after placement to alleviate compaction created by placing the soils.

Water and freeze/thaw is the cause of almost all slopes failures, and the tableland above the slope will always have a low point into which flows from surrounding lands are focused (Glenn Harrington, pers. comm., September 24th 2009). As such, surface flows need to be accommodated to reduce the potential for slope failure, particularly in cases where the slopes are newly seeded and therefore most vulnerable to erosion. Water must be captured and allowed to travel down the slope in a controlled manner in some form of engineered channel.

The rehabilitation of the Shek O Quarry in Hong Kong included the construction of channels that were cut into the site's rock slopes and linked with the drainage hydrology to allow for drainage of flows across the slope. These features were constructed in a manner to maximize their aesthetic appeal and also their integration into the surrounding landscape, while still serving their primary role of channelling water from the tableland to the toe of the slope (Figure 3).

The incorporation of horizontal benches into slope designs contributes significantly to improving overall stability, improves infiltration and associated groundwater recharge, and also facilitates access for seeding and maintenance (Johnson, pers. comm., 2009). When working with parent material and rough grading, the sloping of the material should be rough or corrugated to provide stability. Machinery should be run up and down the slope to leave horizontal tracks. If machinery travels across the slope, the equipment can leave tracks that funnel water down the slope (Harrington, pers. comm., 2009).

The vertical faces of a quarry are either backfilled with waste rock or overburden to create a slope no steeper than 2:1, or a cliff or partial cliff are left with a talus slope created at the base. If there is an abundance of overburden and soil, this material can be backfilled to create the talus slope. Alternatively, the talus slope is created by planning for the last blast along the limit of extraction to create a slope at the bottom of the face (see Figure 2). This material can then be left as rock rubble, or covered with overburden and topsoil to create a better growing medium, depending upon the availability of soil. If soil is not that plentiful, it is better to focus on areas of growth and place a significant depth on some areas, while leaving others uncovered. Providing a range in depths and sizes of materials making up the talus will ensure a greater variety of habitat types for various species of both fauna and flora (TOARC 2008).

**Figure 3 – Constructed Watercourse: Shek O Quarry, Hong Kong Island, China (Credit: J. Forbes)**

There has been some experimentation with using a different design on the last blast in quarries, so that contrary to the normal blast which leaves a smooth, stable face, the last blast leaves a rougher, more textured face. This provides more diversity at the toe of the slope and on the quarry slope face with shade areas, ground water seeps and crevices for growth. Some sites in the UK have had problems with rock fractures after a number of years, as it appears to be a more unstable face. These rough blasts are also more costly and in some cases do not maximize resource extraction. Companies are experimenting with this technique, with varying degrees of success (Cripps et al. 2002; Jim 2001). This approach is discussed in greater detail in Chapter 9.

There has also been experimentation in the UK with replication restoration, where the top of the face is rounded off to match in with the topography. From a distance there is not the stark contrast of a vertical face. The significant drawback is that the setbacks cannot be accessed to improve rehabilitation techniques, as site plans require they remain undisturbed. Therefore in order to implement this concept, significant reserves would have to be left in the ground to provide for the rounding at the top of the face within the limit of extraction.

Some of the old abandoned quarries are rich in diversity and new ecosystems have very successfully adapted and thrived. In most cases there has been little done to rehabilitate these sites, but due to natural growing conditions and good hydrology, succession has occurred. Additional examples of various approaches to the restoration of quarry floors and walls and to both active and passive rehabilitation of slopes are found in 9.

### 3.1.4 Introducing Plant Species and Communities

Once the soils are replaced, the site should be revegetated as quickly as possible to prevent erosion. For rehabilitation to natural heritage features, this also initiates natural successional processes. The chances of a diverse mix of floral species recolonizing a site passively is low if there is not a nearby population producing seed, and this renders abandoned sites highly susceptible to more aggressive, generally non-native species.

In order to select the most appropriate species for a given site, it is helpful to have an understanding of the biophysical and chemical makeup of the soils. Consideration of soil texture, drainage, and amount of organic matter will all influence the survival of selected species. Further information on nutrient assessment and soil testing is available through the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), and can be found on their website at: www.omafra.gov.on.ca/english/crops/pub811/2testing.htm. The active revegetation of sites should be sourced from locally indigenous stock, with the use of locally indigenous native plants and seed mixes. Consideration should be given to the surrounding landscape, in the case of rehabilitation to natural heritage land uses, to ensure compatibility with the surrounding habitats (David Beamer, pers. comm., September 24th 2009).

Plant materials should be selected based on soil type, drainage, soil nutrients and organic matter content, etc. The species selected for rehabilitation should be early successional, drought-resistant, tolerant of full sun, and native to the region. Ideally, the final list of species should include a mix in order to maximize diversity and, by extension, resilience to disease and pests and also suitability for native wildlife. It is clear that one of the limiting factors around plant material selection and acquisition is the relative unavailability of native and endemic stock in quantities sufficient to undertake large-scale rehabilitation. Some suggestions for addressing this are included in the recommendation section of this chapter.

*Mulch*

The application of mulch such as straw creates a microclimate that protects the soil against both dessication and erosive forces, and may be very useful for end land uses such as agriculture and forest. Straw is also a potential food source for micro-organisms such as certain fungi and bacteria, so the combination of this and the creation of a microclimate that increases temperature will contribute to greater survival and growth of micro bacteria and fungi. Straw has a high carbon concentration (vs. hay) and in order for it to decompose, it pulls nitrogen from the soil so the addition of fertilizer may be necessary to compensate for this. In general, the greener the straw, the higher the nitrogen content (Harrington, pers. comm., 2009). Straw mulch typically favours agricultural uses, whereas woody mulches tend to be recommended for rehabilitation to natural heritage end land uses (Mark Browning, pers. comm., August 14th 2009; John Klironomos, per. comm., August 14th 2009).

Contrastingly, the application of mulch is generally discouraged for certain end land uses that are characterized by nutrient-poor soils (e.g. alvars, fens, and prairie and savannah habitats). In these cases, amendments to the soil may be necessary to reduce the levels of nitrogen and/or phosphorus (Mark Browning, pers. comm., August 14th 2009; John Klironomos, per. comm., August 14th 2009; TOARC 2008).

*Seeding*

Seeding sites is a low cost and relatively quick way to re-establish vegetation; however, it can also have a low germination rate and therefore a lack of coverage   Many commercially available seed mixes tend to be dominated by fast-growing but typically non-native and often invasive species. For the first few years, it is currently recommended that crops introduced to a rehabilitated site should include the use of those that are soil binding or nitrogen fixing such as legumes (e.g. clover; alfalfa; birdsfoot trefoil; and crown vetch). Crops such as corn deplete nutrient content and as a row crop it is susceptible to erosion. Annual rye and buckwheat are considered excellent nurse crops (Harrington, pers. comm., 2009); however, while non-native seed mixes are effective in ‘greening up’ sites, they can also interfere with the establishment of native species (Beamer 2007).

The majority of the Task 1 sites being rehabilitated to natural heritage/open space have been seeded using commercially available mixes as suggested by the most abundant species found across the sites. Many of these species are non-native and often invasive, and particularly in cases where the sites do not have a surrounding seed source the succession of the sites to a more natural habitat with a diverse range of native species may be significantly curtailed. In fact, Browning and Tan (2002) note that the traditional approach of spreading overburden, grading and seeding with an exotic seed species mix only makes a difference to plant community structure in the short-term and that after about 10 years these rehabilitated sites mimic abandoned sites.

*Planting - Trees and Shrubs*

MNR developed "The Seed Zones of Ontario" map which is a useful tool in determining appropriate species of trees for a given geographic area (http://www.mnr.gov.on.ca/en/Business/Forests/2ColumnSubPage/STEL02_166255.html). In general, it is recommended that seedlings be used over more mature trees and shrubs since they tend to have a higher survival rate (Lowe 1979; David Beamer. pers. comm., OSSGA Rehabilitation Workshop and Tour September 24th 2009). The use of tree shelters for deciduous trees with biodegradable plastic tubing may be advisable to prevent or minimize grazing and to provide a moist micro-climate once they are planted (Browning, pers. comm., 2009).

Types of plants include:

1. Bare-root: these are often used because they are cheaper, but because they have no soil around the roots, they are highly susceptible to stress. These plants must be transplanted when they are still dormant. While young deciduous trees may be bare-root, coniferous seedlings should have some soil around the roots in a root ball or pot, as they require greater protection.

2. Plugs: these have a high mortality rate and are prone to competition; however, because they do have soil around the roots, they tend to withstand transportation better and the roots tend to be less prone to drought.

3. Container stock: these have the highest rate of survival and are most resistant to shock. However, container stock is more expensive and requires a greater amount of room to transport.

In some cases, there may be opportunities to transplant more mature trees and/or shrubs either from other parts of the site or even from sites that are external to the aggregate pit or quarry. These actions would require consideration for the potential effects on existing, stable vegetation communities. Similarly, there may be opportunities to salvage native plant materials from sites that are being cleared for other reasons (e.g. development, agriculture, recreation such as golf course, etc). If this option is pursued, the transplanted individual should include the maximum amount of root possible and the roots should be pruned prior to transplantation. The individual must be dormant during transplantation, and it is recommended that the roots be cut the year before transplant, as this will force the roots to grow nearer to the base and improve transplant survival. While this approach ensures instant results, there tends to be a low survival rate (David Beamer, pers. comm., September 24th 2009).

*Timing and Care of Plant Materials*

The ideal time to plant trees and shrubs is in the early spring (after frost to mid-May), with planting in the fall generally having a lower survival rate and planting in the summer having a very low survival rate. If trees/shrubs cannot be planted immediately, store them along side each other in a trench in a sheltered area with the roots or root ball covered with moist soil and they may be kept healthy for a week as long as they are kept moist. If there is a water body, the trees/shrubs should be placed by the edge of the water body with the roots in the water and in shady areas (David Beamer, pers. comm., September 24th 2009; Lowe 1979; Hilditch 1988).

### 3.1.5 After-care of Rehabilitated Pit and Quarry Extraction Sites

The management of rehabilitated sites for a period following completion is highly recommended and may include the following:

1. Watering of plant materials for the first year;

2. Mowing of areas recently planted with trees for 3-5 years to reduce competition until seedlings become established;

3. Levelling since lands may subside and in some cases this may affect surface drainage; although this might not be desirable where an interest in diversity establishment through micro topography is expressed;

4. Stone picking since cultivation and frost action may bring stones to the surface and they may require removal – this might only be required for agricultural uses and/or where routine seasonal and annual equipment access to the field is necessary (i.e., agriculture);

5. Incorporation of organic matter since the addition of green manure and/or animal manure will enhance the nutrient content of the soil and may be applicable for certain land uses such as agriculture and forest. This will also help to promote the establishment of appropriate fungal dominated soil necessary for the growth of certain plants;

6. Chemical fertilizers may be required for crop growth, but a soil test should be conducted to indicate the current fertility status of the soil; and,

7. Monitoring changes in soil character, relief, fertility, and plant growth may necessitate the need for changes to the post-rehabilitation plan.

## 3.2 Rehabilitation of Pits and Quarries: Contrast

The progressive rehabilitation of pits and quarries advocates the minimization of the area under extraction at any given time, rapid stabilization of soil materials, and the early assessment of rehabilitation success to allow for the identification of any shortcomings and the associated implementation of adaptive management strategies.

However, pits or quarries that have permanent plants cannot have rehabilitation of the plant site until the site is fully extracted. This leads to a larger disturbed area to accommodate the plants and associated stockpiles. The larger the plant, the larger the stockpile area and the higher the production ability.

Specific methodologies are discussed in greater detail below, identifying the differences between wet and dry, pits and quarries.

### 3.2.1 Comparing and Contrasting Pit and Quarry Methodologies

Pit Above the Water Table

Above-water pits can be rehabilitated as soon as the resource is removed. Some pits have extractable materials that vary in quality. Areas of the pit with poorer quality of material tend to be extracted more slowly as these materials are blended, over time with the higher quality material on site. This can result in larger areas of a licence remaining open to optimize resource extraction and blending on that site.

The use of heavy machinery such as motorized scrapers, front-end loaders, or bulldozers can result in soil compaction during periods of active extraction as well as during reapplication of soil. During rehabilitation, compaction can be minimized by working under dry conditions and using equipment that minimizes soil compaction (exerts pressures less than 1-2 $kg/cm^2$). Such equipment tends to be wide tracked (e.g., crawler tractor) and smaller machinery with rubber tires.

In some cases, the pit floors will require ripping to a depth of at least 1 metre prior to soil replacement in order to avoid natural soil cementation leading to 'hard pan' development and an associated impenetrability of these areas to plant roots (Hilditch et al 1988). Surface soil compaction, less than 30 cm deep, can be lessened using a chisel plough. Where depths are greater than 30 cm, subsoilers or rippers should be used. Rippers mounted on the back of crawler tractors are preferred on sites where materials below the pit floor are stony. Ripping should only be carried out in dry conditions as ripping during wet conditions can significantly damage the soils. The direction of ripping should always consider the effects on drainage, with ripping along contour lines having the least effect and with ripping diagonally to the slope encouraging some drainage of the ground.

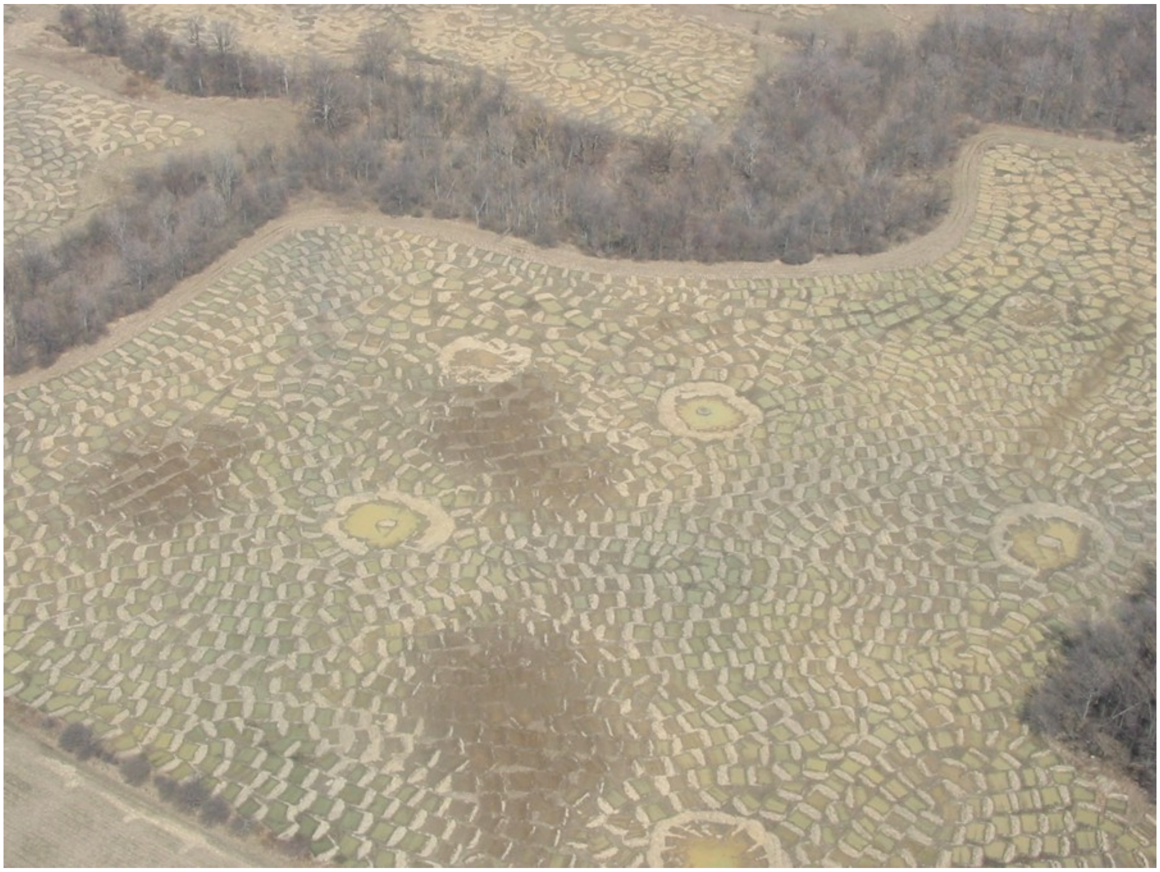
Fine grading is completed by applying a layer of topsoil at a minimum depth of 15-20 cm (Lowe 1979; Mackintosh and Mozuraitus 1982; Hilditch et al 1988). For agricultural lands, the productivity can be improved by 'stone picking' since this will increase the volume of soil available from which plant roots can extract water and nutrients (Mackintosh and Mozuraitus 1982). Some soils may be harder and take longer to fully rehabilitate, with soils with higher clay content generally being the most difficult. Such soils tend to be encountered in overburden situations (e.g., some quarries) versus in pits where soils throughout are more granular.

Mackintosh notes that soil restoration occurs over a longer time frame. Some soils require decades or more to recover and/or to be fully rehabilitated, but Mackintosh advises that virtually all soils can be restored, given that period of time (Erv Mackintosh, pers. comm., August $14^{th}$ 2009).

Maximizing micro- and macro- topography into those sites where the end land use is natural heritage will have the added benefit of maximizing habitat diversity. Browning and Tan (2002) found that the Roadway Pit in Whitchurch/Stouffville possessed the greatest diversity in habitat, including terraced slopes, mounds of sand, piles of boulders, and cemented gravels all of which contributed to significant species' diversity. Site 120 presented an interesting approach to rehabilitation to natural heritage including the use of a technique known as 'pit and mound' that seeks to mimic the natural micro-topography of older growth forests with a view to increasing infiltration and maximizing biodiversity. Other successful examples of the manipulation of topography to influence diversity and climatic variables at various spatial scales are discussed in more detail in Chapter 9.

The Nature Conservancy of Canada has experimented with the 'pit and mound' technique at Clear Creek Forest in southwestern Ontario, and found success with the medium sized pits as far as being most natural in appearance, in addition to retaining water for sufficient periods of time to support successful amphibian breeding. This approach is discussed in greater detail in Chapter 9.

**Figure 4 – Pit and Mound Technique: Clear Creek Forest, Nature Conservancy of Canada (Credit: Nature Conservancy of Canada)**



Conversely, where the end land use is agriculture, there is often an advantage in the elimination of micro-topography in favour of smooth fields, easily accessible by machinery and with well-drained soils.

Agricultural rehabilitation requires the greatest amount of overburden and topsoil, and soil depths less than 0.5 m over bedrock or permanent water table will not likely allow for certain end land uses such as forest or certain crops (e.g. speciality fruit production). Mackintosh and Mozuraitus (1982) recommend that a minimum of 1.2 m of topsoil/subsoil (1 m subsoil; 15-20 cm topsoil) overlying the saturated zone is necessary for adequate plant growth during growing season; in fact, the Provincial Standards of the ARA requires that a minimum of 1.5 m of material be kept in place between the pit floor and the water table. They found that extraction below this depth frequently resulted in saturated water conditions and a resulting degraded growing medium. Mackintosh and Hoffman (1985) suggest that optimum conditions for the rehabilitation of sand

and gravel pits for fruit production are: variable topsoil depth; minimum 1.2 m total soil depth; gravely sandy loam to sandy loam texture; 40-60% porosity; rapidly to well drained; and a minimum 1.2 m depth to water table.

Certain natural heritage features prefer a thin layer of topsoil (e.g., alvars), with parts of the Fletcher Creek quarry having acquired alvar-like characteristics (Figure 5).

**Figure 5 – Fletcher Creek Quarry: Alvar-Like Habitat**

In other instances, it may be desirable to encourage saturated soil conditions in order to create wetland habitats such as fens (Mark Browning, pers. comm., August 14, 2009). Browning and Tan (2002) note that the Fletcher Creek quarry includes a rich fen that has developed on marl deposits associated with a seepage zone that resulted from the blasting of an old narrow outlet channel. Similar conditions at the Wildwood Pit Complex support a fen community that also supports the only known location for cotton grass in Oxford County (Figure 6).

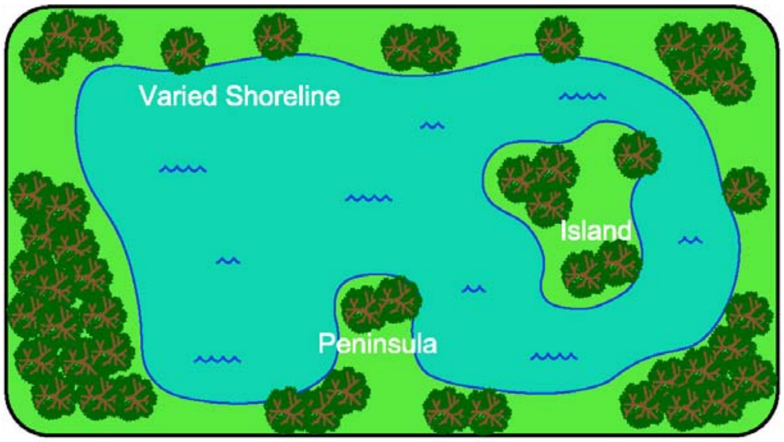
**Figure 6 – Wildwood Pit Complex: Fen Community (Credit: Mark Browning)**

Pit Below the Water Table

Excavating below the water table will inherently eliminate opportunities to rehabilitate to agricultural land uses and terrestrial natural habitat unless inert fill materials are used to raise the elevation of the pit floor or permanent pumping and/or drainage systems are designed and installed to lower water tables through use of interceptor drains and tile drains. There may be potential concerns over the use of inert fill materials associated with the quality of the materials and potential impacts to the intercepted groundwater; however, this would be evaluated on a case-by-case basis (David Webster, pers. comm., August 14, 2009).

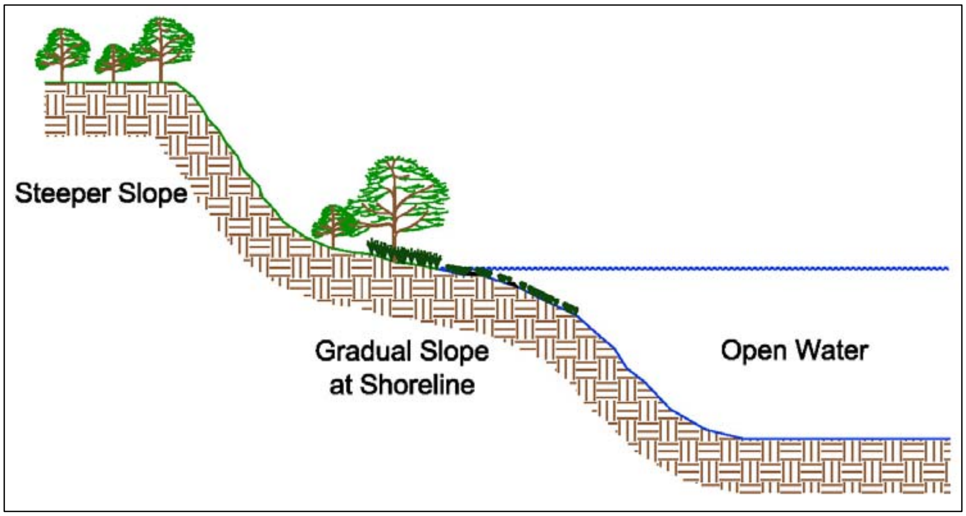
Pits that have been excavated below the water table provide an opportunity for creating a new ecological system. The depth of this excavation, amount of edge area and shallow slopes all determine the types of features that can be reintroduced or created on the site. Often with pit extraction there is an opportunity to either leave poorer quality material in place or to replace the material to create a varied and interesting shoreline, including peninsulas and islands (see Figure 7).

**Figure 7 – Creation of Peninsula and Islands**




Where lakes or ponds are the result of aggregate extraction, efforts should be made to ensure that the water body maximizes benefits to fish and wildlife by creating some gentle slopes along the shoreline that will allow for the growth of nearshore aquatic vegetation (see Figure 8). Open water features observed at the Task 1 and 2 sites did often demonstrate areas of nearshore habitat diversity and associated aquatic plant communities; however, it was not clear if this was the result of deliberate manipulation or more likely an unanticipated consequence of extraction and passive rehabilitation.

**Figure 8 – Cross Section of Shorelines**



Below-water pits may lend themselves well to the creation of a range of shallow and deep water wetland habitats, particularly where extraction depths below water are more limited (i.e., more shallow water bodies). There are several different types of wetland habitats found in Ontario including swamps, marshes, bogs, and fens. Rehabilitation of pits and quarries to both marshes and fens has met with some success, while swamps will sometimes develop over time as marshes succeed usually to shrub thicket swamp and over a longer period of time to treed swamp.

Quarry Above the Water Table

In some cases, no soil is necessary to restore certain habitat features. For example the research related to abandoned limestone quarry floors in Ontario revealed that while these harsh site conditions appear to have prevented colonization by common species in the surrounding landscape, species characteristic of geographically distant but ecologically analogous natural limestone pavements (alvars) can thrive on the quarry surface (Browning 1998; Tomlinson et al. 2008) (Figure 5). Similarly, exposed cliff faces created during quarrying in Ontario revegetate slowly and support only a subset of the species pool inevitably immigrating to cliff microsites; namely, those adapted to extreme physical conditions occurring on natural cliff faces of the Niagara Escarpment (Ursic et al. 1997). Approaches to revegetating cliff-faces are discussed in Chapter 9.

Overall, there may be instances where the use of more or less soil, or its more strategic placement across sites is warranted in order to allow for a diverse mix of habitat types in the case of rehabilitation to natural habitat, or to ensure that its use for agricultural end land uses is focused in those areas that will be under active production (Mark Browning, pers. comm., August 14, 2009; John Klironomos, per. comm., August 14, 2009; and Ken Zimmerman, pers. comm., August 14, 2009).

Quarry Below the Water Table

Below-water quarry floors differ from below-water pits in that they are pumped to keep water out of the quarry during extraction, and the water is allowed to fill once extraction is completed. As a result, many of the quarries show little sign of rehabilitation until the final stages of development. Quarries could be extracted in cells, allowing each cell to fill with water as it is depleted, but that would require leaving a significant amount of resource in the ground. Some quarries (e.g., Nelson Burlington quarry), are rehabilitated in stages by establishing berms on the depleted, final quarry floor, allowing isolated lake filling and wetland creation, in advance of the full quarry becoming available for rehabilitation.

In some quarries where extraction is below the water table and the water elevation is predicted to rise to a specific elevation, vertical benches are usually left. Shoreline treatments vary with 2:1 slopes or cliffs to the water's edge. Shallows and graduated depths of water are frequently lacking due to the uniform nature of the deposit and the desire to optimize resource extraction. In terms of deliberate manipulation of quarries, one old quarry in Ontario featuring a deep lake and steep cliff faces used blasting and heavy construction equipment to collapse the cliff into the lake and reshape the area into a series of shallow pools to be colonized by calcareous fen species (Duval et al. 2007).

These deep lake habitats present some challenges to the establishment of a diverse and productive system. Open lake surfaces might be interrupted by the introduction of vegetation that typically requires shallow water conditions. Floating cattail mats (on created structures), for example, are used in various applications to introduce shallow water systems artificially into these deep water settings (Scientific Review Panel (SRP), October 14, 2009). There may also be an opportunity to construct structures such as rock piles and log structures on the quarry floor before flooding with a view to maximizing habitat diversity for aquatic fauna. Any variety in topography on the quarry floor, which is typically quite flat, is advantageous in terms of fish habitat enhancement. Habitat structures may also be anchored to the rock walls remaining after extraction, close to the future water surface (final rehabilitated level) to introduce some specialized habitat conditions.

Below-water extraction may also allow for the creation of wetlands such as fens and open water habitats. Browning and Tan (2002) have observed the establishment of vegetation characteristics of fen communities at a number of former aggregate quarries such as Fletcher Creek quarry. These conditions are feasible in more shallow water conditions, where final rehabilitation does not include the establishment of a deep water lake.

# 4.0 APPLICATION OF METHODOLOGIES

## 4.1 Factors Affecting Application of Methodologies

The three main factors that affect the methodologies applied to progressive and final rehabilitation include the quality and amount of soil available, elevation of the water table, including; depth to water table, whether the pit or quarry is above or below the water and depth of water body, and adjacent land use.

Soil

In order to experience successful rehabilitation, it is critical to understand what type of soil is available, how much is available, and the rehabilitation program should be designed accordingly.

The amount of overburden and soil present on a site plays a large part in the final rehabilitated landscape. Depending where the site is located geographically, there could be an abundance of topsoil, subsoil and/or overburden that can be used for rehabilitation. Some quarries to the west of the Greater Toronto Area (GTA) have a large supply, and as a result, the quarries in this area can have varied shorelines, peninsulas and varied depths of water. Similarly, many pits in south western Ontario have significant amounts of overburden and soil and this can be used for final grading and establishing planting zones. Although moving this amount of material can be costly and cumbersome from an operational perspective, it provides a variety of opportunities for rehabilitation (Ken Zimmerman, pers. comm., August 14, 2009).

For pits and quarries in areas of the province where there is a thin layer of soil or sites that pre-date the requirement to keep all soil on site, the lack of soil greatly limits rehabilitation options and limits opportunities to create a varied landscape. It is apparent in these areas (e.g. Carden and some areas of the Oak Ridges Moraine) that rehabilitation should encourage natural heritage features that will establish in these harsher conditions, or material must be imported to the site to provide an enhanced organic growing medium. There are also some examples of sites experimenting with developing their own organic layer on site by planting crops and then tilling them into what soil is available (David Beamer, pers. comm., September 24, 2009).

Water

Licenced pits and quarries are approved to either extract above or below the water table. In almost every case, if a quarry is extracting below the water table, ground water and collected surface water is pumped out of the quarry so that extraction occurs in a dry environment. An operating quarry appears to be above the water table. Pits on the other hand, are not pumped dry, and equipment such as a dragline is used to scoop the sand and gravel out of the 'pond' with stockpiles are created adjacent to the water.

There are cases where pits below water have been filled in with fill material to create dry land, and there are cases where there will be continued pumping of the rehabilitated quarry site after rehabilitation. However, these cases usually have a specific reason for keeping the site dry and most pits and quarries below the water table will revert to a water body. Appropriate design is important to maximize the opportunities this new feature will provide both to the public and the natural environment. Understanding final water levels, flow through (i.e. will the site have stagnant water?), water depth, substrate, shorelines and access all should be considered as part of progressive and final rehabilitation.

Surrounding Land Use

In any re-development of a property, surrounding land use and natural habitat play a large part in understanding the best use for the property and how that site will eventually function. There is an opportunity to maximize the results of rehabilitation by recognizing what the surrounding lands have to offer the site, and what the site has to offer surround lands and communities. For example, recognizing surrounding seed sources for natural heritage rehabilitation, tying in with surrounding landforms, providing needed community services such as a water source or recreation complex, will all benefit the final land use.

## 4.2 Applications – What Works and What Doesn't Work

Most properties reviewed as part of Task 1 and 2 have slopes of 3:1 in pits, and quarries are either 2:1 slopes or a combination of cliff faces and talus slopes. Grading also tends to be uniform with little variation in topography. Seeding is commonly used to stabilize soils, but the mixes used are generally widely available, commercial seed mixes dominated by non-native and often invasive species. These mixes will assist in minimizing erosion; however, particularly in instances where there is little to no available seed source in the surrounding landscape, the species' makeup will not continue to succeed to a healthy and biodiversity-rich natural habitat.

Comments received indicated that most operators try to comply with their site plans, which do not have the flexibility to add more variety in the rehabilitation methodologies. There is a process to amend site plans; however, depending on the significance of the revisions required, the process could be costly and time consuming. As a result, most operators are hesitant to update their site plans to allow more creative rehabilitation This is further compounded in some instances where there is a lack of expertise and available resources to individual site owner/operators to undertake rehabilitation.

What Works

Techniques that have proven to be successful include:

i) The physical conditions – hydrology, soil/substrate and topography must be assessed and developed correctly for individual sites and after use;

ii) Equipment operators need to be educated so they understand the sensitivity of soil handling and the goals for the final landscape;

iii) Chisel ploughing to alleviate compaction from the rehabilitation process of soil replacement is necessary, if the goal is to create a growing medium;

iv) Pit and mound rehabilitation of slopes instead of grading provides a variety of topography and micro topography. Water can be trapped in the pits and reduces the erosive force and increases decomposition;

v) Tall grass prairie seeding works both with and without topsoil. It takes longer to germinate and grow than non-native species; it will take 2-3 years to see a biomass of tall grass prairie. The benefit is more root growth, more drought resistance and low requirements for organics. The result is a long term benefit for the site;

vi) Smaller stocks for tree planting – seedlings less than a foot, are most successful. Larger trees are more expensive, and due to losses, after a couple of years the seedlings have caught up. There is however, a narrow window of when to plant;

vii) Bare root tree stock works best when it is planted directly into soil with no requirement for temporary storage;

viii) Tree shelters for deciduous tree plantings prevent grazing and provide a moist micro-climate. The plastic tube that surrounds the trunk is degradable and eventually breaks down;

ix) If there is no soil available, 3 gallon container stock works well, and is easy to transport. It also has a long window for planting;

x) In very droughty conditions (e.g. alvars), oats or rye can be planted to "green things up". Mulches in this case can assist in the early growth;

xi) Any time there is water on the site it is a good thing, as water is an accelerator of nature;

xii) If quarries can have an outflow (natural or man-made) so water can move through the system, there is more cycling, and a better response by nutrients; and

xiii) Monitoring and assessment of successes, so that future rehabilitation plans can be adapted accordingly (adaptive management plan). This leads to a more successful rehabilitation process.

What Doesn't Work

Techniques that have been unsuccessful or not cost effective include;

i) Planting seed or non-potted trees too late in the year . Timing is dependant on species planted and local timing of frost;

ii) Non-native seed mixes that are water and fertilizer dependent. While these might appear successful after a month, years later they can become desolate and sparsely vegetated;

iii) Planting species that do not match with the physical conditions;

iv) Quarries below the water table with no shallows around the edges – this creates a monoculture with very little diversity or opportunity as an after use; and

v) Trying to get rehabilitation to go one way, when nature wants it to go another.

# 5.0 PROVINCIAL POLICIES AND LEGISLATION

The ARA does not provide specifics in terms of how and when rehabilitation shall take place on any given site. The Act requires that progressive and final rehabilitation occur and the standards provide minimum requirements regarding slopes and soil replacement. As such, the approaches to rehabilitation have been largely decided upon by individual aggregate producers, sometimes in discussions with other parties (e.g., municipalities, conservation authorities), based on surrounding land uses and post development opportunities.

The Provincial Policy Statement (PPS) (MAH, 2005) states that progressive and final rehabilitation of mineral aggregate operations must consider surrounding land use and accommodate land use compatibility. Given the diversity of land use options in Ontario (agriculture, development, environmental conservation, etc.), there is an opportunity for the reintroduction of restored land into the surrounding landscape matrix to satisfy several provincial, regional and/or local planning objectives. Rehabilitation of pits and quarries can potentially support the following provincial initiatives, legislations, and plans:

*Initiatives*
Ontario's Biodiversity Strategy
Natural Spaces Program
Ontario Tourism Strategy
Wine Council of Ontario Action Plan
Ontario Trails Strategy: Active2010

*Legislations and Plans*
Greenbelt Act, Greenbelt Plan
Niagara Escarpment Planning and Development Act, Niagara Escarpment Plan
Oak Ridges Moraine Conservation Act, Oak Ridges Moraine Conservation Plan
Clean Water Act and the Lake Simcoe Protection Plan
Planning Act and the Provincial Policy Statement
Places to Grow Act and Growth Plan for the Greater Golden Horseshoe
Endangered Species Act and the Federal Species At Risk Act

This section provides an overview of the ways in which pit and quarry rehabilitation can support each of the provincial planning / guidance documents listed above.

## 5.1 Initiatives

### 5.1.1 Ontario's Biodiversity Strategy (OBS)

The dual goals of Ontario's Biodiversity Conservation Strategy are:

1. Protect the genetic, species and ecosystem diversity of Ontario; and,

2. Use and develop the biological assets of Ontario sustainably and capture benefits from such use for Ontarians.

In order to integrate biodiversity conservation into land use planning, this strategy states that a natural heritage system and supporting connectivity within this system must be identified. Task

#24 of the OBS (Government of Ontario 2005) recommends that existing natural linkages should be retained or re-established between natural areas with a high priority on reducing landscape-level habitat fragmentation in southern Ontario. By extension, ecological restoration of appropriately selected pits / quarries can support this component.

The OBS also emphasizes the following:

- The urgent need to recognize the importance of green spaces and conserving biodiversity in planning rules and processes (e.g. importance of ‘healthy ecosystems - healthy communities);

- Importance of education in biodiversity for youth (e.g. pit/quarry rehabilitation sites that provide natural heritage interpretation / outdoor hands-on experiences that connect youth with nature can encourage interest in this field); and

- From a pit/quarry rehabilitation perspective, the above components could translate to simple initiatives, such as providing interpretive signage, hiking trail systems, opportunities for nature observation / enjoyment (picnic areas, bird viewing boardwalks / look-outs), and opportunities for connection to school curriculum (e.g. pond studies).

#### 5.1.1.1 Case Study: Sites 115, 120, and 121 and Nelson Aggregates

Site 115 has actively engaged the local community, including the local boy scouts in the rehabilitation of the site through extensive tree planting initiatives. Similarly, Sites 120 and 121 both have tree planting events that are open to the community and specific groups such as boyscouts and schools.

In 2008, the Nelson Aggregate Company undertook a partnership with CANPOLIN (Canadian Pollination Initiative) and the University of Guelph by providing pilot study areas on the rehabilitated slopes of their Burlington and Cambridge aggregate properties. These areas were rehabilitated with species that are attractive to pollinating insects and a comprehensive monitoring program was initiated. This initiative will not only contribute to gaining a better understanding of the ecological role of pollinating insects, but will also directly contribute to creating additional habitat for these declining taxa.

These initiatives directly contribute to the OBS's objective of educating youth in the importance of biodiversity, while also achieving the broader objectives of increasing and re-establishing biodiversity in Ontario.

### 5.1.2 Natural Spaces Program

The Natural Spaces Program aims to reduce the loss of natural areas or "green space" in southern Ontario. The main priority is to encourage protection of existing natural areas and restoration of degraded natural areas.

The Natural Spaces Program's associated "Nature Counts" discussion paper (Canadian Urban Institute, 2006) which focuses on the socio-economic value of southern Ontario's natural heritage stresses the importance of citizen stewardship involvement. Completed pit/quarry rehabilitation sites that allow public access for passive recreation or active participation in ongoing community projects (e.g. "greening" or biodiversity initiatives) could complement the objectives of the Natural Spaces Program. Community involvement in stewardship activities is also considered an important component in the evolution and maintenance of 'healthy communities and healthy ecosystems' due to economic, social, health, and environmental benefits accrued to the participant and the broader community.

#### 5.1.2.1 Case Study: Timber Brothers Gravel Pit

In 1998, the former Timber Brothers Gravel Pit (Township of Uxbridge) was purchased by the Toronto Region Conservation Authority (TRCA) and a phased approach to rehabilitation was initiated (see Figure 9). The work has included grading to 3:1 slopes, creation of berms, extensive plantings, the construction of trails and lookouts and the installation of interpretive signage (see Figure 10).

Included in the longer-term plans for this site is the establishment of a "Living Classroom" to demonstrate the role of various restoration techniques in increasing biodiversity, while also contributing to nature-based recreation activities. The site will continue to undertake applied research to gain a better understanding of various approaches to the restoration.

This initiative not only helps to address habitat loss and to restore degraded areas, but also provides areas for nature-based recreation and contributes to public education concerning the importance of biodiversity and the role that rehabilitated pits and quarries can play in reversing trends in biodiversity loss.

**Figure 9 – Former Timber Brothers Gravel Pit - 1998 (Photo Credit: Lou Wise)**

**Figure 10 - Former Timber Brothers Gravel Pit - 2008 (Photo Credit: Lou Wise)**

### 5.1.3 Ontario's Tourism Strategy and the Wine Council of Ontario Action Plan

Prime agricultural land protection also ties in with Ontario's Tourism Strategy (Ontario Ministry of Tourism, 2004) and the Wine Council of Ontario's "Strategy and Action Plan for Wine and Culinary Tourism in Ontario". The Ontario Tourism Strategy highlights the untapped potential of Ontario's tourism industry, low relative provincial tourism returns and the under-utilization of natural assets (regarding winery/ culinary tourism and eco-tourism / natural heritage attractions). Pit or quarry rehabilitation that is able to support / benefit prime agricultural land on-site or benefit adjacent prime agriculture lands (e.g. by providing a natural heritage attraction or environmental education opportunities that could be incorporated into a tourism experience) could promote the provincial tourism strategy.

#### 5.1.3.1 Case Study: Site 128

Site 128 directly contributes to both Ontario's Tourism Strategy and the Wine Council of Ontario Action Plan in the rehabilitation of the site to a vineyard in the Niagara region.

### 5.1.4 Ontario Trails Strategy – Active2010

The economic impact of physical inactivity is a recognized emerging issue in North America and for Ontarians. The Ontario Trails Strategy "Active2010" (Ministry of Healthy Promotion, 2005) recommends that all adult Ontarians walk a minimum of 30 minutes daily or participate in some other equivalent activity. Pit and quarry rehabilitation designs that incorporate walking / biking / or off-road vehicle trial systems, etc., can directly benefit this strategy and the local community. Environmentally sensitive trail design, safety and accessibility are high priorities outlined by the Ontario Trails Strategy.

In addition to helping Ontarians stay active and achieve a higher quality of life, creating a trail system can also foster development of healthy communities by providing a recreation opportunity that is accessible to a broader spectrum of the population (e.g. youth, children, women, new Canadians, low-income groups and persons with disabilities). Designing trails that attract these citizen groups is a challenge and opportunity that could be addressed through targeted quarry rehabilitation.

#### 5.1.4.1 Case Study: Site 120 and Miller Paving Limited

A portion of the Bruce Trail traverses part of Site 120's unlicenced lands, demonstrating that active pits and quarries, along with inactive and rehabilitated sites can contribute to broader provincial initiatives.

Miller Paving Limited was contacted by the Township of Uxbridge to see if they would be interested in a partnership that would allow the Trans Canada trail to traverse along the northern and western boundaries of their licenced pit in Uxbridge Township (designated Trail Capital of Canada in September 2009). This would enable a continuous trail connecting an unopened Road Allowance and Durham Country forest, thereby providing a "missing link" in this section of the trail. Miller was supportive of the idea and after considerable time, effort and cost (MNR required de-licensing of the proposed trail), there is a 10 m easement with a registered agreement and plan, allowing public access on Miller's property (Tom Jones, per. comm., 2009).

## 5.2 Legislations and Plans

### 5.2.1 Greenbelt Act

The Greenbelt Act (2005) includes lands within by the Oak Ridges Moraine Conservation Plan, the Niagara Escarpment Plan, and the Parkway Belt West Plan Area. The Greenbelt Plan identifies three specific land types that occur within the Protected Countryside designation: Agricultural System, Natural System, and Settlement Areas.

New mineral aggregate operations and wayside pits and quarries are not permitted in significant wetlands, significant woodlands and in the significant habitat of endangered and threatened species, but are permitted in other key natural heritage or hydrologic features subject to demonstrating the protection of water quality and quantity, connectivity between key natural heritage features and key hydrologic features and consistency with the Provincial Policy Statement. New mineral aggregate operations and wayside pits or quarries will only be permitted in certain portions of specialty crop areas where it is demonstrated that the physical characteristics of the proposed site will allow for rehabilitation back to an agricultural condition which allows for: (1) the same range and productivity of specialty crops common to that area; and, (2) for the necessary microclimate on which the site and surrounding area depend for specialty crop production.

The Plan requires that progressive and final rehabilitation efforts to '*contribute to the goals of the Greenbelt Plan*' which include: protection of agricultural areas; protection, maintenance and enhancement of natural heritage, hydrologic and landform features; and the promotion of infrastructure and natural resources to meet socioeconomic needs balanced with the protection of natural heritage features and functions.

The rehabilitated area of pits and quarries is to be maximized, and the disturbed area minimized. Time frames are specified for the rehabilitation of excess disturbed area in existing pits and quarries. Final rehabilitation of operations in the Natural Heritage System is also subject to policy related to specific minimum requirements for forest cover representative of the natural ecosystem, and the maintenance, restoration and where possible improvement of connectivity with key natural heritage and hydrologic features on and adjacent to the site.

#### 5.2.1.1 Case Study: Site 128

One excellent example from the Task 1 sites is number 128 that is found on the Niagara Escarpment and within the Greenbelt. Consistent with both the Greenbelt Plan and the Niagara Escarpment Plan, the site owners have undertaken extensive rehabilitation to speciality crops; in this case, the end result is a vineyard. Some experimentation has been undertaken to plant vineyards on the rehabilitated side slopes, and paper mill biosolids have been used to amend the soils by integrating organic matter. Much of the land is tile drained and prior to seeding, the soils were chisel ploughed, disked, cultivated, fumigated and fertilized and then seeded with a mix of perennial rye, birdsfoot trefoil, and fescue, and finally left fallow for several years prior to planting the vines. The thickness of the overburden is about 1-2 m, and the average topsoil thickness is 10-15 cm.

This site is also surrounded by agricultural lands, so it is well integrated into the surrounding landscape. Grapes were first harvested from this site in 2002, and the site was given OSSGA's Award of Excellence in 2005. The site was also given an award by the Niagara Escarpment Commission for undertaking immediate rehabilitation by stripping the soils for extraction and then transporting them directly to the rehabilitated areas. This site is not only consistent with the Greenbelt Plan specific objectives as far as agricultural protection is concerned, but it will also successfully exceed the objective of partial completion of rehabilitation by 2011.

## 5.3 Niagara Escarpment Plan

Regarding rehabilitation of mineral resource extraction areas, the Niagara Escarpment Plan (NEC, 2009) outlines two main objectives:

- Ensure that after uses and rehabilitation are compatible with the applicable Plan designation, the surrounding environment and existing uses; and
- Encourage integration of rehabilitated quarries into the Niagara Escarpment Parks and Open Space System.

Below is a summarized excerpt from NEC (2009, p. 72-73) regarding more detailed rehabilitation requirements:

- Where rehabilitation is being undertaken by reforestation, the after use shall aim to re-establish a functioning ecosystem similar in condition to the natural ecosystems in the region.
- The rehabilitated site shall have minimal impact upon the surrounding natural and visual environment and existing uses.
- Where the rehabilitation is being undertaken to agriculture, substantially the same acreage and average soil capability for agriculture shall be restored.

Rehabilitation shall incorporate the following:

- Excess topsoil and overburden are to be retained and stabilized for future rehabilitation.
- All excavated pit walls are to be regraded to a slope of 3:1 or less, except in regions where topsoil and fill materials are scarce. In such areas finished slopes may be no steeper than 2:1. Exposed sections of pit or quarry faces may be left intact for aesthetic or educational purposes as incorporated into an approved after use plan.
- Vegetation, including seeding, crops or trees and shrubs, shall be planted as soon as possible following finished grading.

NEC (2009) encourages the integration of rehabilitated quarries into the Niagara Escarpment Parks and Open Space System, which lists the following objectives:

- Protect unique ecological and historical areas;
- Provide adequate opportunities for outdoor education and recreation;
- Provide for adequate public access to the Niagara Escarpment;
- Complete a public system of major parks and open space through additional land acquisition and park and open space planning;
- Secure a route for the Bruce Trail;
- Maintain and enhance the natural environment of the Niagara Escarpment;
- Support tourism by providing opportunities on public land for discovery and enjoyment by Ontario's residents and visitors;
- To provide a common understanding and appreciation of the Niagara Escarpment; and
- Show leadership in supporting and promoting the principles of the Niagara Escarpment’s UNESCO World Biosphere Reserve Designation through sustainable park planning,

ecological management, community involvement, environmental monitoring, research and education.

Rehabilitation of a given pit or quarry to a natural heritage and/or passive recreation after use could potentially satisfy several of the above-noted objectives. In order for pit/quarry rehabilitation initiatives to further the objectives of the Niagara Escarpment Plan, the following points are important considerations: ensuring that rehabilitation design fully considers both existing and proposed surrounding land uses and are nested in a landscape context; considering inclusion of value-added features (e.g. interpretive signage, increased biodiversity seeding/planting, viewshed observation points, trail systems, etc.,), and permitting public access. Certain land use classifications of the Niagara Escarpment Plan do not encourage public access, such as 'nature reserves' and potentially 'resource management areas'. The latter classification allows for an increased emphasis on natural resources (e.g. forest products, fish, wildlife, flood control).

#### 5.3.1.1 Case Study: Site 120

Site 120 is being rehabilitated to natural heritage, with efforts made to ensure full integration with the surrounding landscape. Peat has been retained and is being integrated into the rehabilitation that also includes the use of the 'pit and mound' technique in order to maximize the collection and temporary retention of water on-site (i.e., the hollows established will collect and pool water and will tend to gather leaf litter and to promote decomposition). Efforts are also being made to use stones and other materials to create additional wildlife habitat including hibernacula and various refugia. Adaptive management is being applied to the rehabilitation of the site to ensure that the approach is adjusted to incorporate newer science recommendations, such as the use of a greater range in species' diversity and the use of native species.

## 5.4 Oak Ridges Moraine Conservation Plan

The Oak Ridges Moraine Conservation Plan (2002) includes four key land use designations: natural core areas, natural linkage areas, countryside areas, and settlement areas. The Plan sets out a series of objectives including:

- Protect the ecological and hydrological integrity of the ORM Area;

- Ensure that land and resource uses are restricted to those that maintain, improve, or restore the ecological and hydrological functions of the ORM Area;
- Maintain, improve or restore all the elements that contribute to the ecological and hydrological functions of the Oak Ridges Moraine Area, including the quality and quantity of its water and its other resources;
- Ensure that the Oak Ridges Moraine Area is maintained as a continuous natural landform and environment for the benefit of present and future generations;
- Provide for a continuous recreational trail through the Oak Ridges Moraine Area that is accessible to all including persons with disabilities; and
- Providing for other public recreational access to the Oak Ridges Moraine Area.

No new aggregate resource extraction is permitted in Natural Core Areas. New mineral aggregate operations and wayside pits are permitted in the natural linkage and countryside areas if they can demonstrate that:

(1) Water quantity and quality will be maintained, improved, or restored;

(2) The maximum amount of the site will be rehabilitated to either agricultural use in the case of prime agricultural lands, or natural heritage for non-prime lands;

(3) The health, diversity, size and connectivity of key natural heritage features will be maintained, improved, or restored;

(4) if there are (earth science) ANSIs on the site or adjacent lands, that the geological or geomorphological features for which they were identified will be protected; and

(5) within Natural Linkage areas, no extraction will take place within 1.5 metres of the water table, and an excluded area of at least 1.25 kilometres in width shall be retained to maintain connectivity.

The ORMCP also encourages the municipalities and the mineral aggregate sector work together to develop and implement comprehensive rehabilitation plans for those areas affected by mineral aggregate extraction.

#### 5.4.1.1 Case Study: Uxbridge Pit

Lafarge Canada has undertaken an interesting approach to the rehabilitation of their Uxbridge Pit in a manner that directly contributes to both the OBS and the Oak Ridges Moraine Conservation Plan. When the ORMCP came into force in 2001, Lafarge took the opportunity to revise the site plan that was originally aimed at rehabilitating the site to agricultural end land use. With a view to undertaking a comprehensive rehabilitation strategy, they incorporated the following into the plan:

- Mature forest community consistent with the surrounding landscape;
- Focus on re-establishing linkages and interior forest habitat; and,
- Incorporation of agricultural lands into the front of the site.

Lafarge incorporated nodal / cluster plantings into the site design, in addition to solid plantings, and also transplanted existing vegetation into the new areas. They also engaged the local boy scouts in the tree plantings. Future efforts will be focused on the incorporation of rock piles and brush/stump piles to maximize wildlife habitat diversity. Since 2001, over 58 hectares have been rehabilitated in a total licenced area of 183.95 ha (Sergio Carbone, pers. comm., September 24, 2009).

## 5.5 Clean Water Act

The Clean Water Act (2006) is aimed at protecting existing and future sources of drinking water and requires the development of local source protection plans to protect vulnerable aquifers or recharge areas. The reports shall identify and characterize all watersheds in the source protection area and highlight any existing or potential threats to the quality and/or quantify of the water within those areas.

The rehabilitation of aggregate pits and quarries that maintain or enhance water quality and quantity through the creation of features such as wetlands, enhancements to the soil makeup, or specific slope treatments such as terracing to maximize infiltration has the potential to contribute to furthering the objectives of the Clean Water Act.

#### 5.5.1.1 Case Study: Site 120

The integration of the ‘pit and mound’ technique into the rehabilitation of Site 120 will serve to maximize the collection and temporary retention of water on-site (i.e., the hollows established will collect and pool water and will tend to gather leaf litter and to promote decomposition) (Figure 11). While this site is still under progressive rehabilitation, ultimately this will serve to contribute to retaining water on-site for longer periods of time and to improving overall recharge of local and regional groundwater supplies. The use of peat materials will also contribute to filtering the water and contribute to water quality improvements.

**Figure 11 – Site 120 – Progressive Rehabiltation: Application of Pit and Mound Technique (Credit: Dufferin Aggregates)**

## 5.6 Planning Act

The Planning Act sets out the framework for land use planning in Ontario and seeks to balance socio-economic with ecological considerations throughout the province. The Act provides the basis for the preparation of Official Plans that, in turn, guide future development.

### 5.6.1 Provincial Policy Statement

The Provincial Policy Statement (PPS) is issued under Section 3 of the Planning Act and provides direction related to land use planning and development and, more specifically, includes policies related to specific matters of provincial interest such as natural heritage, prime agricultural lands, and mineral aggregate resources.

#### 5.6.1.1 Natural Heritage Systems

The PPS (MAH, 2005, p.33) defines a *natural heritage system* as being comprised of natural heritage features and areas, linked by natural corridors which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species and ecosystems. The Natural Heritage section of the PPS (MAH, 2005) states that, "*natural connections between natural features should be maintained and improved where possible*". In conjunction, the OMNR (2000) Significant Wildlife Habitat Technical Guide (SWHTG), which defines significant wildlife habitat features outlined in the PPS, stresses the important role natural corridors play in connecting fragmented natural areas and facilitating movement of flora / fauna.

The SWHTG highlights several of the benefits of adding corridors to a natural heritage conservation system, such as:

- May increase dispersal abilities of many wildlife species and help maximize biological diversity;
- Helps offset the negative impacts on wildlife of highly fragmented landscapes;
- May increase habitat and populations of some species; and,
- Corridors may also function as buffer zones, by protecting natural areas and their ecological processes from adjacent land use activities.

Conversely, the SWHTG states that loss of wildlife movement corridors makes species more vulnerable to predation and disturbance. Local populations of some species may even be extirpated due to absence of corridors. Similarly, habitat destruction and fragmentation is a common threat to many species at risk in Ontario. Efforts to restore connectivity to the natural landscape can benefit rare plants and animals that depend on dispersal to maintain or expand existing populations.

The existing and predicted stresses of climate change on biological community's demands the presence of natural movement corridors in order to facilitate adaptation to changing temperature, habitat, food availability, migration routes, etc. Adjustment of species' ranges in order to cope with changing environmental conditions is expected to spur movement of many species (both native and non-native). Providing suitable pathways to accommodate this shift can help to support species during this crisis (UNEP / CMS, 2006). Reducing anthropogenic pressures, such as habitat loss / fragmentation, is a crucial measure to facilitate biodiversity protection and ecosystem resilience (UNEP / CMS, 2006).

Ecological restoration of a pit or quarry to fit into the surrounding natural landscape can reconnect or strengthen such natural corridors that provide some or all of the above-noted functions. The OMNR (2000) provides the following recommendations to identify the best scenarios for the restoration of ecological linkages. These features can be utilized to strategically select pit and quarry sites that are the best suited for this purpose.

- Corridor protects animals from road mortality (highest priority sites are those with low road density)
- Corridors should be as continuous as possible (some, more porous gaps may be acceptable e.g., farmland)
- Limit barriers to movement within a corridor (high quarry walls or quarries excavated below water-level may pose a barrier to some species but opportunity for others)
- Shorter, wider corridors are the most desirable
- Restore corridors that link important natural areas or wildlife habitats
- Natural areas that have been historically isolated should not be connected - the quality of areas that are to be potentially connected should also be considered (e.g. poorly placed / designed corridors may provide a conduit for colonization and dispersal of invasive species into a high quality community).

**5.6.1.2 Case Study: Cedar Ridge Aggregates**

Cedar Ridge Aggregates in Lochiel Township is an interesting example of a smaller producer where the landowners took an active interest in the rehabilitation of the pit. The sand and gravel was extracted to a clay hard pan layer, after which the site owner approached the local saw mill to obtain organic waste material at no cost. He allowed the material to decompose for about 4-6 years and for the acidity of the mulch to decline, after which he planted evergreens. Using various indicator species to gauge the progression of the site, he then incorporated additional species including native willows and dogwoods, allowing for the gradual succession of the site to a mixed wood forest. The Ontario Stone, Sand and Gravel Association (OSSGA) issued an award to the site in recognition of this innovative approach to rehabilitation (David Willis, pers. comm., October 13, 2009).

#### 5.6.1.3 Prime Agricultural Land

According to the PPS (MAH, 2005), extraction of mineral aggregate resources is generally permitted on prime agricultural land provided that much of the site is restored to the same average soil quality for agriculture. Complete agricultural rehabilitation is not required on prime agricultural lands, if:

- The quarry is extracted below water table, or the depth of planned extraction makes restoration of pre-extraction agricultural capability unfeasible;
- Other alternatives have been considered by the applicant and found unsuitable - in this case prime agricultural lands shall be protected in this order of priority: specialty crop areas, Canada Land Inventory Classes 1, 2 and 3; and
- Agricultural rehabilitation in remaining areas is maximized.

The rehabilitation of aggregate pits and quarries could potentially provide further benefit to prime agricultural land by applying soil restoration / management techniques to upgrade originally sub par soils (Class 4-7) or to prepare Class 1-3 soils or specialty crop areas for use. This could be achieved through a range of soil restoration and nitrogen management techniques, such as mycorrhizal fungi soil inoculation, cover crop planting, and nutrient adjustment applications. Opportunities to incorporate pest management (invasive plants, insects) into rehabilitation plans could also be explored (e.g. heavily weed-infested soil could potentially be restored to more functional agricultural land through rehabilitation efforts).

Specialty agricultural crops (e.g. tobacco, ginseng, mushrooms, wineries, dry beans, apiculture, agroforestry, hemp, landscaping nurseries, greenhouse crops, etc.) receive the highest priority for protection (MAH, 2005). In some cases, all or part of the rehabilitated pit or quarry may be able to support specialty crop operations (e.g. appropriate forage for honey production, soil conditions for sugar maple or Christmas tree plantations, forest-based non-timber products, etc.). While plantations are an agro-forestry use, they can also augment surrounding natural heritage systems; for example, they may serve a connecting function or buffer a natural area.

In addition, the provision of agricultural land can be compatible with natural heritage objectives, such as connecting or buffering animal movement corridors / environmental linkage areas. Many animals will move freely across farmland to access natural areas (less-intensively farmed areas provide more opportunities for wildlife functions, such as foraging, roosting, nesting, etc.). Protection of prime agricultural land is also a requisite of the Greenbelt Plan.

#### 5.6.1.4 Case Study: Capital Paving Inc. Pit #2, Puslinch Township

Capital Paving Inc undertook the rehabilitation of Pit #2 in Puslinch Township to agriculture as an end land use. Prior to extraction, this site exhibited low fertility, desiccation, and stoniness. As part of the rehabilitation, the topsoil and subsoil were screened and approximately 40 cm of subsoil and 20 cm of topsoil were replaced on the graded pit floor and side slopes. The site was fertilized and seeded with a mixture of alfalfa, timothy, brome grass, and clover and orchard grass. This approach resulted in improved yields over the pre-extraction conditions. (http://www.capitalpaving.net/m/content/article.php?content_id=12)

## 5.7 Places to Grow Act and Growth Plan

The Places to Grow Act and the Growth Plan for the Greater Golden Horseshoe Plan (MPIR, 2006) support and build on the Provincial Policy Statement, Greenbelt Plan, Niagara Escarpment and Oak Ridges Moraine Conservation Plans. The plan (MPIR, 2006) provides policies for how and where urban development should best and most appropriately occur. The plan encourages development of a 'culture of conservation' and outlines policies for managing natural systems, prime agricultural areas, and mineral aggregate resources. The following list provides excerpts from the plan that are more relevant to pit and quarry rehabilitation.

- Section 4.2.1 (p. 31) Policies for protecting natural systems
  - Encourage linking / enhancing natural systems;
  - Encourage development of a system of publicly accessible parkland, open space and trails that is based on (a) a co-ordinated approach to trail planning development, (b) good land stewardship practices for public / private lands, and (c) which clearly demarcates where public access is permitted.
- Section 4.2.2 Prime Agricultural Areas
  - Encourage municipalities to maintain, improve and provide opportunities for farm-related infrastructure such as drainage and irrigation; and
  - Encourage municipalities to establish and work with local agricultural advisory committees and to consult with them on decision-making related to agriculture.

- Section 4.2.3 Mineral Aggregate Resources
    - Consider opportunities for coordinated approaches to rehabilitation where feasible.

Overall, in terms of application to quarry rehabilitation, the Places to Grow Plan (MPIR, 2006) emphasizes the need to develop collaborative, coordinated approaches to land management. The importance of protecting and enhancing prime agricultural areas (sustainable locally grown food), natural areas, and developing a trail system (addressed previously under separate documents) are also highlighted.

#### 5.7.1.1 Case Study: Site173 – Mississauga Development

The former Cooksville Quarry located north of Dundas Street, east of Mavis Road in the City of Mississauga has been fully redeveloped for urban uses. The 68 hectare quarry was active within the built up area of Mississauga until surrender of the licence in 1998. The lands have been developed for a wide range of uses with relatively dense single detached and townhouse dwellings surrounding an elementary school, baseball diamonds, soccer pitches and playground. A naturalized open space around a stormwater management pond is also part of the central recreational area. The school and recreation facilities are linked by walking/bicycle paths. Commercial uses, including a grocery store and home improvement store have been developed on the site adjacent to the intersection of Dundas and Mavis, and a smaller commercial plaza is located on Dundas more central to the site. The area west of Mavis Road is primarily industrial uses that existed at the time the area was developed.

This development is a good example of the kind of "complete community" envisioned by the Growth Plan for the Greater Golden Horseshoe where people may walk, or cycle to school, recreational facilities and shopping. There is access to transit on adjacent arterial roads and on the collector road through the development with direct access to the Cooksville Go Station. There is also potential for employment in the immediate area reducing the need for long range commuting.

**Figure 12 – Former Queensville Quarry - 2009 (Photo Credit: VuMap)**


## 5.8 Endangered Species Act and the federal Species at Risk Act

Ontario's Endangered Species Act (2007) and the federal Species at Risk Act (2002) are both aimed at preventing the loss of wildlife in Ontario and Canada, and call for the development of recovery planning documents that set out activities necessary to recover designated species at risk. Recovery teams specific to both individual species/groups of species and/or ecosystem types are composed of experts, who could serve as a source of assistance to the aggregate industry in identifying priority areas and actions for recovery of individual species and habitats.

There is an opportunity for rehabilitated pits and quarries to contribute directly to addressing habitat loss and degradation – particularly where sites are located in the current or historic range of species at risk (TOARC 2008).

### 5.8.1 Case Study: Bowmanville Cement Plant

St. Mary's Cement Inc. - Bowmanville Cement Plant provides habitat for the Peregrine Falcon, designated as threatened under the Ontario Endangered Species Act. In fact, the extraction activities themselves created the habitat - a cliff face - that is now used regularly by a pair of breeding Peregrine Falcons. The pair has selected this artificial habitat for nesting, suggesting that the current operations do not adversely affect the falcons (Figure 13).

**Figure 13 – Bowmanville Cement Plant: Male Peregrine Falcon on Quarry Face**
**(Photo Credit: Doug McRae)**

## 6.0 CURRENT SCIENCE AND POLICY: BRIDGING THE GAP – CONCLUSIONS AND RECOMMENDATIONS

Rehabilitated pits and quarries have the potential to support and contribute to many of Ontario's socio-economic and ecological initiatives and policies. As evidenced by the preceding discussion, there is a wide range of examples where both small and large scale producers have already directly contributed to advancing many provincial objectives.

As the science related to restoration ecology continues to advance, there is an opportunity for productive partnerships amongst aggregate producers, the industry association, government, non-governmental organizations, service clubs, and academia. The potential to draw upon research being conducted by some groups (e.g., academia) and implement it in the field by others (e.g., aggregate producers, service groups), is not fully tapped. Many opportunities exist to benefit from a deeper understanding of the rehabilitation of disturbed ecosystems.

The Scientific Review Panel workshop drawn together for this study provided an opportunity to generate and to discuss ideas around a diversity of technical rehabilitation topics. Research, innovations and various practices were discussed, with some of the many comments being incorporated into this report. A key contribution was the definition of areas that would benefit from some ongoing and specific research.

There are some limitations in the current science and also in the flexibility of some of the planning and policy tools, including rehabilitation site plans. There are barriers to the advancement of best rehabilitation practices that can be addressed in part by the removal of some of those barriers and in part through the encouragement of more innovative and effective rehabilitation through recognition programs and perhaps through specific encouraging tools.

There is a need to update some of the current science recommendations to better reflect today's standards, but also a need to ensure that this information is shared with the broader industry, including producers and Aggregate Resources Officers. The following are some specific recommendations for consideration:

1. Encourage the establishment of a Scientific Review Panel or Committee with appropriate scientific and policy expertise. That team would have an ongoing role of ensuring current scientific thinking is vetted and provided to the province on a regular basis. This might best be accommodated within existing aggregate and/or scientific units of the MNR. It could be further facilitated by the creation of a research and best practices coordination position (Rehabilitation Specialist) within the Aggregates program.

2. Develop an annual research list in collaboration with TOARC to ensure that the research activities are optimized and to ensure the results are communicated broadly. Ideally, the industry and Aggregate Resources Officers would provide input into this list so that the most critical needs are met first, with additional feedback from the broader research community to allow for exchange of ideas and concepts.

3. Build upon existing relationships with Academia and collaborate to ensure existing specialty programs address restoration capacity building (e.g., Sir Sandford Fleming College, University of Trent, Niagara College).

4. Continue to develop Best Management Practices and associated guidance documents for industry.

5. Continue to examine the policies and accepted practices around soil requirements in rehabilitation. There are many ecological niche communities that can be established effectively with limited soils. Consider the appropriateness of increased flexibility around soils (e.g., aesthetic berms) where it might not be helpful to the end use and rehabilitation process.

6. Encourage innovation and the creation/retention of interesting features (e.g., alvars, fens, cliff and bank faces, floating islands, sheltered cliff perches, etc.).

7. There is currently a disconnect for owners/operators between the conservation and/or enhancement of habitat for Species at Risk and the retention of their right to extract licenced material under the ARA. While the aggregate industry has the land base, and access to proven scientific and technical methodologies to create and protect habitat, the successful creation, enhancement, and protection of habitat to benefit Species at Risk could curtail or shut down the operation.

8. Engage in discussions with Ontario's landscape nursery and seed industries to foster a dialogue that will lead to more commercially available endemic plant materials and preferred seed mixes.

9. Enable partnerships to occur between producers and stakeholders without penalty or hardship to either (e.g. public use of licenced lands).

10. Consider opportunities for the development of funding mechanisms to assist in the delivery of recommended programming. This recommendation is one of the most

important of this study. Financial resources will need to be put in place in order to see the real change that is achievable for pits and quarries.

A number of the issues raised and recommendations noted above echo those published in Aggregate Resource Research Strategy - Workshop Proceedings (Fraser and Ward, 1995) . The list of participants and the Summary of Proposed Research Strategies are included in Appendix 2, to re-iterate the importance these concepts and the common goals determined by independent groups.

# APPENDIX A

## Scientific Review Panel Workshop

## Participants and Notes

Scientific Review Panel: Workshop

Holiday Inn, Mississauga – October 14th 2009

Mark Browning, Restoration and Rehabilitation Research Biologist, Ministry of Natural Resources

Anne Guiot, Senior Planner, Skelton Brumwell

Kate Hayes, Senior Ecologist, Savanta Inc

Tom Hilditch, President, Savanta Inc

Brian Hollingsworth, Policy Officer, Planning / Project Manager – SAROS, Ministry of Natural Resources

John Klironomos, Professor, University of British Columbia

Dan Kraus, Manager of Conservation Science, Nature Conservancy of Canada

Erv MackIntosh, Agronomist, Independent Consultant

Jon McCracken, Director National Programs, Birds Studies Canada

Doug McRae, Ornithologist, Savanta Inc

Paul Richardson, University of Guelph

David Webster, Hydrogeologist, Ministry of Natural Resources

Ken Zimmerman, Manager of Aggregate Development, Essroc

Chris Zoladeski, Botanist, Savanta Inc

**SAROS TASK 6**

**SCIENTIFIC REVIEW PANEL WORKSHOP: NOTES**

**OCTOBER 14, 2009**

## SOILS

- Need to first consider the target crop/community
- The use of fertilizers for example will result in consequences for natural community creation (increased weediness)
- Don’t amend tallgrass prairie with chemical N or with N fixers
- Limit nutrients and free N in prairie restoration and with natural restoration generally
- Coarse textured soils easier to restore
- One of the best indicators of soil quality is bulk density
- Soil restoration requires longer term thinking (i.e., 20 – 50 year processes)
- The soil system is more resilient than we expect
- Mycorrhizal inoculants are available but are limited
- Not always necessary to replace soil; sometimes succession gets a good start with limited soils and nutrients; favours colonization by early successional ssp
- High nutrient soils can trigger weediness
- Some are growing native mosses on gravel, without soil
- Berms for aesthetics (i.e., berms not required for noise reduction, visual screen, mandated by MNR) should be excluded in favour of better use of soils
- Older sites; shouldn’t need to strip and stockpile; should be able to move directly to replacement without storage
- Need to add organic matter using a high carbon:nitrogen ratio (better to use woody mulches instead of straw) for naturalization vs chemical fertilizers for agriculture

## MICRO-DRAINAGE

- Micro-topography is a strong influencing factor in terms of natural succession and the development of biodiversity
- Hollows serve to accumulate leaf litter and to facilitate the accumulation of debris, accelerating organic decomposition
- 3:1 slopes should not be necessary where agriculture is not the proposed end use; benefits associated with varied and in some cases steeper slopes
- Steeper slopes can, however, lead to erosion issues
- Water Table; above versus below classification of licences was established early on in response to the selection of a water table level that would facilitate agriculture
- A 1.2m depth to water table enables crop production; nothing to do with safety of ground water quality and/or risk management
- The 1.2m objective was agriculture related – problem is that it eliminates the possibility of adding wetlands, vernal pools and seasonally wet meadows; deceases the potential for insect, amphibian and small mammal usage
- Some direct connect with ground water and impoverished water quality can assist in fen restoration (e.g., Fletcher’s Creek);
- Pit and mound promotes natural regeneration
- More regeneration occurs around pit edges

**PLANTING**

- Live transplant is helpful (i.e. seedbank)
- The longstanding recommended MTO seed mix is a minimum standard; full of invasives and exotics – tends to arrest natural vegetation succession
- 10 years after seeding, there has been limited advancements to natural succession that has begun with seeding that mix
- Need to kickstart succession versus aggressive seed mixes
- Commercial supplies of indigenous, local stock are hard to find; quantities are too small to be helpful in larger rehab projects
- Consider the creation of on-site nurseries to supply on-site stock
- Encourage dialogue with the nursery industry to develop innovation and partnerships
- Dog-strangling vine, buckthorn dominated systems require a change in the trajectory of succession
- Understand and benefit from natural seed rain
- Work with natural systems
- Plant clusters well away from seed rain areas which will have seed rain available versus cluster plantings

**WILDLIFE**

- Cliff swallow use of cliffs; potential for artificial bank/cliff faces
- Swallows feeding over open water may be enhanced through open water rehabilitation
- Think about rehab sites and open water in terms of creating an insect factory to encourage insectivorous bird/bat feeding
- Overhanging rock lip will encourage peregrine nesting
- Microtopography and water are key characteristics for rehabilitation to enhance insects/fauna
- Explore and test pilot created habitat structures (e.g., floating islands)
- Explore rock fissure and crack establishment

**END USE**

- End use determination is key to optimizing rehab planning, implementation and protection of investment
- Assuming agriculture and/or forestry; topsoil quality and depth and subsoiling are key factors
- Assuming Natural heritage; need to design based upon water table level (above or below water extraction) and soil characteristics (i.e., present, absent)
- Need to have enough flexibility to design and plan for end use
- Historically the end use was typically agriculture and some to forestry and wildlife habitat restoration
- Over the past 20 years there has been a shift away from agriculture and forestry towards aquatics and now to more specialty ecological purposes
- A whole new range of ecological end uses has developed (e.g., specialized communities such as fens and alvars)
- The replacement of topsoil was always a key determinant for agriculture and forestry
- Agricultural crops are not mycorrhizal dependent; they have short nutrient and nitrogen cycles that are artificially maintained
- Natural systems have slow nitrogen and nutrient cycles
- Manure is rich in organic and N; well-suited to agriculture
- Not so for some specialty ecological purposes, in fact it might be at cross purposes to special ecological end uses, where soils need to be unfertilized and
- Proper stripping, stockpiling and replacement of topsoil was able to successfully achieve about 75% of former crop yield
- Other factors such as ripping and sub-soiling took that to 95%

- Some specialty crops are relatively easy to rehabilitate to given their tolerance of more granular and less fertile soils (e.g., grapes).
- These specialty crops depended more upon micro-topography to facilitate cold air drainage
- The initial objective might be open space or natural heritage however, in some cases these uses are changed in response to market and/or other conditions
- How can investments in natural heritage rehabilitation be protected or limited?

**PROCESS/REHABILITATION PLANNING**

- High risk and lengthy approvals processes do not encourage risk-taking and/or innovation in terms of rehabilitation
- There is more room for "arm's length" research, outside of the approval's process

**POLICY**

- PPS encourages beneficial afteruse
- Licence surrender can sometimes lead to losses of rehabilitation to-date
- Rehabilitation can become an evolution over time of land uses
- Need to create some incentive and/or recognition programs
- Develop better partnerships with key institutions (e.g., Trent University, SSFC, Niagara College)

**FUTURE RESEARCH**

- How to optimize species at risk
- Role of soils bacteria and fungi; how to maintain the network of mycorrhiza
- Development of new innocula that are seral stage and ssp specific mycorrhiza
- Better understand biology of stockpiled soils
- Introduction and colonization by beneficial organisms

**PUBLIC PERCEPTION**

- Public wants clean, park like setting
- That is in opposition to natural heritage
- Tough to communicate scientific information to the public
- Need to educate people about the appearance of sites
- SAROS has started that; how to keep the momentum up
- Need to consider overlapping uses (e.g., source water protection) and communicate same messaging across initiatives
- Need to better communicate applied science
- People expect instant results; need to inform and educate about the temporal aspects of rehabilitation
- Need to create the success stories
- Create the cookbooks of recipes for rehabilitation (e.g., to rare species, to recreation, etc.)
- Can use some rehabilitated sites as living classrooms
- Demonstrate better tie in to Healthy Communities

APPENDIX B

Excerpts of Aggregate Resources Research Strategy – Workshop Proceedings

**Excerpts of Aggregate Resources Research Strategy – Workshop Proceedings**

**November 21, and 22, 1994**

**Leslie M. Frost Center**

## 4.5 DISCUSSION GROUP 5: Rehabilitation

**Facilitator**

Mark Browning
Ministry of Natural Resources

**Participants**

Margaret Cranmer-Byng
Federation of Ontario Naturalists

Sarah Lowe
Aggregate Producers Association

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Township of North Dumfries

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Tom Hilditch
Conservation Council of Ontario

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## 4.6 Summary of Proposed Research Strategies

**GROUP 1: Resource Evaluation and Economics**

1. Revise and update aggregate resource inventory papers.
2. Develop a framework for resolving potentially overlapping provincial planning policies.
3. Undertake research into educational opportunities for aggregate resources management.
4. Extend coverage of GIS resources Mapping in relation to aggregate resources.
5. Evaluate the feasibility of applying Full cost accounting to proposed aggregate extraction.
6. Evaluate the impact of aggregate extraction on surrounding real estate values.
7. Research the costs/benefits of aggregate extraction accruing to municipalities.

**GROUP 2: Aggregate Resource Management: Long-term Protection and Availability**

1. Update aggregate inventory data.
2. Improve aggregate constraint mapping.
3. Assess currently licenced resources.
4. Undertake strategic management planning on a local and regional scale.
5. Develop local structures and processes for resource management decision-making.
6. Develop co-ordinated and proactive approaches to rehabilitation which enhance landscape sustainability on long-term basis.
7. Develop approaches to conservation of aggregate resources.

**GROUP 3: Aggregate Resource Management: Social Context**

1. Develop social impact assessment models.
2. Assess social decision-making and alternative dispute resolution (ADR) approaches.
3. Develop community information transfer strategies.
4. Wayside pits and quarries.
5. Determine impacts of extraction on land values.

**GROUP 4: Environmental Impacts**

1. Develop a cumulative impact assessment model for assessing extraction proposals.

2. Develop tools to give predictable and repeatable results for inventory and assessment surveys.

3. Monitor cumulative effects (spatial and temporal) of water taking and discharge on the water regime of the affected area.

4. Monitor effects of changes in vegetative communities and landform on groundwater.

**GROUP 5: Rehabilitation**

1. Document and assess previous rehabilitation efforts for extent of naturalization and integrity of ecological function.

# CHAPTER 7

# SAROS PAPER 6 REHABILITATION

# OPPORTUNITIES FOR REHABILITATED SITES TO ACHIEVE BROADER HEALTHY COMMUNITY OBJECTIVES

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## TABLE OF CONTENTS

# 1.0 INTRODUCTION

The objective of Chapter 7 was to "*provide a list of opportunities to use rehabilitated aggregate sites to achieve broader healthy community objectives (linkages, forest cover, recreation, conservation, etc.).* Preliminary research included the identification of a definition and key attributes associated with a 'healthy community', with the analysis further advanced through a consideration of examples drawn from both Chapter 5 sites and other examples of rehabilitated aggregate pits and quarries.

This Chapter explores how rehabilitated sites can reasonably contribute to healthy community attributes and is discussed in a summary fashion in the next subsection.

# 2.0 WHAT ARE HEALTHY COMMUNITIES?

Different groups and agencies interpret the term healthy community in a variety of ways. The term "healthy community" was coined in 1984 at Healthy Toronto 2000: Beyond Health Care, and this then inspired the World Health Organization to expand the initiative to a global effort and to establish the Healthy Cities Project office (IHCF, 2009). A review of various online media suggests that the term is used by many international, national and state/province/territory authorities to refer to the creation of communities that are economically viable, include robust natural systems of features/functions and possess social systems that are inclusive and equitable (WHO, 2009).

A suitable generic definition of a healthy community is that it:
*… continually creates and improves the physical and social environments and expands those community resources that enable people to mutually support each other in performing all the functions of life and the development of their maximum potential* (Hancock and Duhl 1986).

In Ontario, The Provincial Policy Statement (PPS, 2005) identifies the importance of building "Strong Communities". That policy statement notes that, "*Strong communities, a clean and healthy environment and a strong economy are inextricably linked*." The PPS (section 1.1.1) notes that, ***"****…healthy, liveable and safe communities are sustained by:*

- *promoting efficient development and land use patterns which sustain the financial well-being of the province and municipalities over the long term;*
- *accommodating an appropriate range and mix of residential, employment (including industrial, commercial and institutional uses), recreational and open space uses to meet long-term needs;*
- *avoiding development and land use patterns which may cause environmental or public health and safety concerns;*
- *avoiding development and land use patterns that would prevent the efficient expansion of settlement areas in those areas which are adjacent or close to settlement areas;*
- *promoting cost-effective development standards to minimize land consumption and servicing costs;*
- *improving accessibility for persons with disabilities and the elderly by removing and/or preventing land use barriers which restrict their full participation in society; and*
- *ensuring that necessary infrastructure and public service facilities are or will be available to meet current and projected needs.*"

A range of provincial ministries as well as upper and lower tier municipal governments share in and collaborate around many aspects of strong and healthy communities. Some have a particular focus on human physical and mental health and accessibility to various health care services (e.g. Ontario Ministry of Health and Long-Term Care, Ontario Ministry of Community and Social Services). Others such as the Ministry of Municipal Affairs and Housing and the Ministry of Energy and Infrastructure have a focus on the planning and physical elements of our communities.

The notion of Healthy Communities is the subject of much interest in the planning profession and is an important core component of most current Official Plan exercises. Beyond government agencies being interested in and supportive of Healthy Communities, the Ontario Provincial Planning Institute (OPPI) has been interested and active in the promotion of Healthy Communities through their 2007 Position Paper and more recently, through the release of their document, "*Planning by Design, A Healthy Communities Handbook*" (Fall, 2009). This OPPI handbook pays particular attention to a planning approach that recognizes the "…*critical role that built environments can play in shaping the physical, psychological and social health of individuals and communities*." The OPPI initiatives speak to rural, urban strategies (e.g., land use patterns, transportation networks, public spaces and natural systems) that affect individual and community health.

A voluntary organization, the Ontario Healthy Communities Coalition (OHCC), notes that social, environmental and economic factors are all important determinants of human and overall community health, with health being considered a state of complete physical, mental and social well being. As such, the pursuit of a "healthy community" will aim to integrate social, economic and environmental goals to benefit the whole community and strengthen its capacity to promote and sustain health (OHCC, 2009).

## 2.1 Healthy Community Attributes

The OHCC (2009) presents a series of attributes of healthy communities including:

1. Clean and safe physical environment;
2. Adequate access to income, safety, work and recreation for all;
3. Opportunities for learning and skill development;
4. Wide participation of residents in decision-making;
5. Strong local cultural and spiritual heritage;
6. Diverse and vital economy;
7. Protection of the natural environment; and,
8. Responsible use of resources to ensure long-term sustainability.

The achievement of healthy community attributes in rehabilitated sites builds upon contributions achieved over the life span of the operation. Active operations contribute directly and indirectly to some attributes, especially those related to local economics, employment and physical community development and infrastructure renewal, and important aspects of public policy (e.g., Places to Grow, Infrastructure Renewal/RENEW). For purposes of this study, analyses are restricted to the achievement of community attributes in a post-operation, rehabilitation context (i.e. 'rehabilitated' pits and quarries).

## 3.0 OPPORTUNITIES FOR AGGREGATE SITES TO ACHIEVE BROADER COMMUNITY OBJECTIVES

### 3.1 Land Uses in Surrendered Sites

As a starting point in assessing potential contributions to healthy communities, this study examined the end uses of the 50 surrendered sites (Chapter 5). Those sites exhibited a range of end uses including natural, open space, agricultural, recreational, residential, commercial, industrial, and institutional. Using the OHCC attributes introduced in section 1.2 of this chapter (left column of Table 1, below) the end uses were considered in terms of their possession of these attributes and/or achievement of these objectives. Table 1 summarizes those analyses. Some additional summary discussion is offered about each of these end uses, following Table 1.

The review of the 50 rehabilitated sites did not provided information relative to the extent of public participation related to rehabilitated land use. However, public input is part of the approval process for aggregate operations both under the Aggregate Resources Act and the Planning Act.

Where sites are to be returned to the pre-licensing or similar land use such as agricultural, natural or open space, a minimum of public attention or debate regarding the end use is the norm. Where sites are to be rehabilitated and developed for more intense uses (e.g. residential subdivisions, active recreation, industrial) where there is more potential for land use conflicts, additional approvals under the Planning Act are usually required. These may occur during the extraction operation or after surrender. In the process for approval of applications for Official Plan or zoning amendments, subdivisions, etc., public consultation will include, at minimum, public notification and public meetings, and may also involve the public in a community open house or design workshop. Therefore, public participation related to final land use of pits and quarries does occur in varying degrees depending on the intensity of development.

**Table 1 Opportunities to contribute to Healthy Communities Attributes**

| Healthy Community Attributes | Land Uses in Surrendered Pit and Quarry Licences | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Natural/Open Space | | Agricultural | Recreational | Development | | | |
| | Natural | Open Space | Agricultural | Recreational | Residential | Commercial | Industrial | Institutional |
| | 9 of 50 Sites | 25 of 50 Sites | 17 of 50 Sites | 5 of 50 Sites | 6 of 50 Sites | 3 of 50 Sites | 5 of 50 Sites | 2 of 50 Sites |
| Clean and safe physical environment | √ | √ | √ | √ | √ | √ | √ | √ |
| Adequate access to income, safety, work and recreation for all | √ | | √ | √ | | | √ | √ |
| Opportunities for learning and skill development | √ | | | √ | | | √ | √ |
| Wide participation of residents in decision-making | | | | √ | √ | √ | √ | √ |
| Strong local cultural and spiritual heritage | √ | √ | | | | | | √ |
| Diverse and vital economy | √ | | √ | √ | | √ | √ | |
| Protection of the natural environment | √ | √ | | | | | | |
| Responsible use of resources to ensure long term sustainability | √ | | √ | | | | √ | |

### 3.1.1 Natural / Open Space

<u>Natural</u>

Pits and quarries that are rehabilitated with consideration to the natural ecosystems of the surrounding landscape can extend and buffer adjacent features thereby contributing to overall landscape cover, resilience, and diversity. Water supplies may be protected and enhanced through increased infiltration due to smaller catchment areas and flattened topography. These areas provide private, and in some cases public, opportunities for passive recreation and access to nature that enhances our quality of life through learning and appreciation of the natural world.

In Ontario, the presence of many aggregate sites near urban areas (i.e. ‘close to market’) suggests that they may, in a rehabilitated state, play a very important role in terms of providing habitat refugia in landscapes that are otherwise low in natural cover and diversity. Whether these species arrive on their own or are deliberately introduced as part of a rehabilitation strategy, this approach fulfills specific attributes associated with a healthy ecosystem.

The rehabilitation of pits and quarries may also provide opportunities to increase landscape-scale diversity and the degree of connectivity amongst natural areas and features. This is especially the case where rehabilitation efforts can be coordinated at a more regional level. Assisted immigration of species from a distant alvar or fen site to a single small quarry located in an agricultural landscape may not yield communities that are sustainable (or “healthy”) on their own over the long term. However, coordinated rehabilitation of multiple sites spanning a broad geographic area with direct connections to natural source communities may achieve just such a goal, with this general topic discussed in greater detail in Chapter 8. What is more, coordinated rehabilitation in such a fashion may also increase the resiliency of source communities, by providing refuge for rare or threatened species with potential to recolonize source sites in the wake of human caused and/or natural disturbances.

The potential clustering of rehabilitated pits and quarries to allow for the creation of a larger total amount of habitat and associated subpopulations of a given species distributed across these sites holds promise in terms of contributing to the recovery of species at risk and to meeting broader biodiversity goals and objectives (Cameron, 2007).

In these ways, these rehabilitated features can contribute to the achievement of objectives under broad policy initiatives such as the Greenbelt Plan, municipal Natural Heritage Systems (i.e., as defined in municipal planning documents) and other more specific initiatives and strategies (e.g., Ontario Biodiversity Strategy, Endangered Species Act and associated stewardship initiatives). Chapter 6 discusses this topic in greater detail.

As shown below in Figure 1, Site 185 is an example of rehabilitation to natural heritage features. A portion of 10-Mile Creek has been restored, within part of a site that is now a municipal landfill. The restoration of the creek contributes to the health of the local community by protecting the natural environment and providing for a clean physical environment.

**Figure 1 – Site 185: Restored banks of watercourse.**

Open Space

Open space areas are often in a transitional stage between the active extraction operation and some future development-oriented land use. While not specifically rehabilitated to recreate natural ecosystems, they provide green open spaces that contribute to overall air quality and community aesthetics, and may be available and suitable for recreational and learning activities. They may also provide temporary in-situ habitat for some species, and stopover areas for other migrant species. Open space areas are also used for stormwater management facilities that assist in maintaining the quality and quantity of surface water features.

As shown below in Figure 2 at Site 181, the floor and slopes of the surrendered aggregate pit have been restored with appropriate grading and vegetation which blends into surrounding grasslands and agriculture. The resultant landform provides a pleasant view very much in keeping with the surrounding landform.

**Figure 2 – Site 181: Grassed floor and slope of previous aggregate pit.**

### 3.1.2 Agricultural

Rehabilitation to agriculture is generally undertaken in areas of prime agricultural lands as is required by the PPS. This returns lands to productive agriculture providing income to the farmer and contributing to the local economy. The agricultural markets are dynamic and have evolved and diversified especially in recent years in response to the consolidation of the commercial distribution system (e.g. establishment of larger corporate farms, able to supply large, consistent volumes of crops with a certain consistency in terms of shape, size and quality). The farming industry has also spawned the emergence of substantial organic and near-urban specialty farms in response to real and/or perceived food safety issues and a demand for specialty crops. Rehabilitated pits and quarries, especially those in a near urban context, offer an opportunity to contribute to these specialty product markets. Ontario has some well-known examples of rehabilitation to tender fruits, which is restricted geographically to certain soils and microclimates.

Shown below in Figure 3, the majority of this small aggregate pit at Site 155 has been rehabilitated back to agricultural uses (currently corn field) thereby contributing to the local agricultural economy.

**Figure 3 – Site 155: Corn field adjacent to surrendered aggregate pit.**

### 3.1.3 Recreational

Recreational uses observed in this study included golf courses, a public park and sports fields adjacent to a school, and a pond and adjacent lands that are owned by a conservation authority but not yet fully developed for recreational uses. These facilities provide opportunities to learn about and develop active lifestyles. They can also contribute to the local economy by providing jobs and bringing people to the area. More specifically, rehabilitated sites have and can continue to help achieve objectives related to active recreation uses (e.g., picnicking, camping, canoeing, watersports, summer and winter trail use, biking and associated active sports and playing fields). Passive recreation activities such as nature observation and birdwatching are well suited to many rehabilitated sites.

The Kelso Conservation Area and associated features (e.g., reservoir at the Hilton Falls Complex) are examples of former aggregate sites that will contribute significantly to the achievement of local and regional recreational objectives along with other important storage and flood control functions.

Figure 4 below at Site 196 illustrates a golf course constructed within a surrendered aggregate pit. Former aggregate pits are excellent locations for golf courses, as they provide ponds, graded lands and a "clean slate" for design. The golf course provides an outdoor recreational opportunity that is suited to, and attractive to, many age groups. Golf courses also provide jobs for residents, contribute to the local economy.

**Figure 4 – Site 196: Golf Course**

### 3.1.4 Development

Residential

Residential housing forms observed in the study of surrendered licences include larger lot single detached in more rural areas, and small lot singles, and townhouses in an urban area. In any new residential development there is opportunity to provide for accessible and affordable housing units.

Residential subdivisions, as shown in Figure 5 at Site 173, are common at surrendered sites in urban areas.  Examples like this site blend well into the surrounding residential and commercial areas.  Many residents undoubtedly are unaware that they live upon a previous aggregate site.

**Figure 5 – Site 173: Residential subdivision**

Commercial

Commercial development on the study sites include grocery stores, a home improvement store, gas station and restaurant.  These uses contribute to the local economy by providing jobs and needed goods and services.

An example of commercial development within surrendered Site 193 is shown in Figure 6.  This site has incorporated many commercial uses into a surrendered site bordering on a major highway.  Typically called "highway commercial" uses, this site includes a gas station, hotel and restaurant as well as office buildings.  All of these uses support the local economy and provide services for highway travellers that may, as visitors to the community, also contribute to the tourism economy.

**Figure 6 – Site 193: Commercial Development**


Industrial

With the exception of a municipal waste disposal site on one property, the sites identified as industrial were still being developed at the time of the study. Industrial uses also contribute to the local economy and provide jobs, and as the "green" industry sector grows will provide the tools to protect the environment as well. Aggregate related industrial uses such as recycling of aggregate, and the production of value added products such as specialty landscape products for golf courses and sports fields and architectural stone help to diversify the economy of the area and represent responsible use of the resource.

Figure 7 shows Site 172, which is located within a major urban area of Ontario and was being development as an industrial business park. This type of development is very well suited for the area, which includes established and newer industrial/business park areas. Employment opportunities and property taxes resulting from this development will contribute to the local economy.

**Figure 7 – Site 172: Industrial subdivision under construction.**

Institutional

The study sites include an elementary school and a government building. These uses provide jobs and learning opportunities. The elementary school, shown in Figure 8, is located at the centre of an urban neighbourhood and appears to be within walking distance of many homes and adjacent to extensive sports fields facilitating an active lifestyle model.

**Figure 8 – Site 173: Elementary school and recreation area.**

## 3.2 Select Examples of the Achievement of Healthy Community Objectives

From a natural environment perspective, rehabilitated sites offer an opportunity to meet specialized objectives such as the conservation and promotion of biodiversity, including the recovery of rare species of plants and animals. Additional examples are provided in Chapters 9 and 10; however, some representative examples follow.

In the United Kingdom, a rare aquatic plant was recently discovered in a flooded limestone quarry (Beecroft et al 2007), while a quarry in Ohio provides refuge for the rare Lakeside Daisy (Hannes and Hannes 1984). Chapter 10 documents many other examples where passively and activated rehabilitated pits and quarries now provide habitat for species that have for the most part arrived at the sites unassisted, suggesting that the conditions are suitable to allow for the establishment of these species.

At Holcim's Los Arnales site in Malaga, Spain, choices in species of plants considered not only the microclimatic conditions of the site but also the makeup of species in the surrounding mountain ecosystems. Additional measures to benefit wildlife included the incorporation of drinking areas and the creation of rabbit warrens. Another example of rehabilitation focused on integration with the surrounding natural landscape and enhancement of habitat for source populations is exemplified through Lafarge's Dinmor Parc Quarry located on the northern coastline of Anglesey in Wales, a designated Area of Outstanding Natural Beauty. In recognition of this designation, Lafarge sought to approach the restoration that would retain to the extent possible remnant semi-natural vegetation (e.g. calcareous grassland and maritime and cliff top grassland) in addition to extending these vegetation types over the extracted areas. The generally nutrient poor substrate associated with the existing bare quarry floors allowed for succession to communities that contain many of the characteristic plant species of the semi-natural vegetation types (David Park, pers. comm., 2009).

At Lafarge's Uxbridge Pit in Ontario, a site plan amendment allowed for the creation of a 110 metre wide forested wildlife corridor, reforested with species reflective of the surrounding landscape. The approach draws from conservation principles related to succession-based design considerations (Trimble and Seibert, 2002), and this ensures integration with the surrounding ecological matrix, restoration of a physical environment that is capable of sustaining populations, and maximization of native biodiversity.

From the multiple perspectives of natural environment, open space/recreation, agriculture and commercial, the rehabilitation of the Don Valley Brick Works afforded the creation of an interesting balance by creating a diverse range of native habitats including wetlands and grasslands, showcasing the history of the site through buildings and an extraction face left exposed and also the integration of a farmer's market that serves the local community (Figure 9). The main focus of this site is to educate the broader public and the residents of the City of Toronto about natural heritage conservation and restoration, and also locally grown food. As such, this site exemplifies several of the attributes related to healthy communities. This site was awarded the Bronze Plaque by the OSSGA in 2000, recognizing outstanding rehabilitation achievements after over 100 years of industrial use.

**Figure 9 – Brick Works**

References to many development examples are found in the literature. The Alamo Quarry Market in San Antonio Texas is described as a true Texas landmark. Once home to the Alamo Cement Plant that helped build Texas for more than 100 years, the Market is now featured as "…an inspired destination for shopping, dining and entertainment…". The Alamo Quarry Market has maintained and integrated some of the original structures of the factory as Regal 16-plex Cinemas, which is constructed around the original smokestacks. These smokestacks are a main focal point of the center and have become an easily distinguishable landmark visible from the highway (http://www.quarrymarket.com/).

Site 155 is 22.1 hectare parcel within 40 hectare licence that was extracted above the water table then successfully rehabilitated to agriculture. Mature woodlands within the licence were excluded from the extraction area. The site would not be recognized as a former pit now. This represents a good example of wise use of resources by providing for extraction of the aggregate resource then restoring the agricultural capability of the land.

## 4.0 CONCLUSIONS AND RECOMMENDATIONS

Rehabilitated pits and quarries have significant potential to meet Healthy Community objectives. Many sites associated with Chapter 5 achieve important natural environment, agricultural, and open space objectives. A smaller number contribute to objectives related to economic and development aspects of healthy communities.

It is reasonable to observe from this study that the degree of contribution to healthy communities can be optimized through:

1. A careful review and consideration of these attributes during the planning of end uses;
2. Consideration of these attributes in terms of the opportunity to meet multiple objectives; and
3. Consideration of objectives across a specific geographic area, terrain, watershed/subwatershed and political jurisdictions.

The optimization of objectives will be facilitated through broad, collaborative dialogue and might be undertaken over specific geographies and/or in specific upper tier jurisdictions. An opportunity to deliberately consider the role of rehabilitated sites across a feature such as the Oak Ridges Moraine, for example, could lead to the identification of broad purposes for select sites or groups of sites. Rather than relying completely upon a site-specific rehabilitation program, a broader context might reveal some important and specialized functions that could be performed by specific sites or groups of sites that would optimize the achievement of healthy community objectives (e.g., concentrated use for specific recreation objectives, importance for landscape connectivity, importance as biodiversity refuges, etc.). This aspect is discussed in further detail in Chapter 8 - Comprehensive Rehabilitation Plans, with additional examples of regionally based approaches to rehabilitation provided in Chapter 9.

Comprehensive planning and decision-making in a Healthy Communities context will lead to enhanced potential and realised opportunities for rehabilitated aggregate sites to achieving a range of socio-economic and ecological objectives that will benefit the landscape and its inhabitants.

# CHAPTER 8

# SAROS PAPER 6: REHABILITATION

# COMPREHENSIVE REHABILITATION PLANS

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# Appendix A

## Stakeholder Contacts for Comprehensive Rehabilitation Plans

## 1.0 INTRODUCTION

The licensing of pits and quarries in Ontario is based on individual applications, and as a result, multiple licences can occur in close proximity, or adjacent to one another. Opportunities exist to combine these licences, but it is not common to see multiple sites combined as part of a comprehensive rehabilitation plan. This study explores what comprehensive rehabilitation plans are, and how they have been successfully implemented. Specifically, the Task is to; *"Discuss the opportunities for comprehensive rehabilitation plans and investigate the opportunities and barriers of the concept both from a resource utilization and integrated rehabilitation viewpoint"*

## 2.0 WHAT IS A COMPREHENSIVE REHABILITATION PLAN?

The location of pits and quarries is determined by the quality and quantity of the aggregate resource. However, the actual size of a pit or quarry is often determined by the land secured for extraction by ownership or lease agreement. It is not uncommon to see 100 acre parcels that are licenced with additional reserves surrounding the licence. The entire resource could be extracted by expansion of the existing licenced operation or by new operators licensing adjacent lands. With different owners extracting the same resource area, and roads acting as natural barriers, it is apparent how an aggregate deposit can get subdivided. When the variables of properties being licenced at different times and companies extracting at different rates are added, integration of rehabilitation becomes difficult to co-ordinate.

For abutting licences where two operators can readily come to a mutual agreement to extract the common setback, amending rehabilitation plans to extract common setbacks and reconcile side slope and pit floor grades, is fairly common throughout Ontario. These are relatively straightforward opportunities to maximize resource extraction within licenced properties and provide a more useful rehabilitated landscape. This process usually requires a site plan amendment under the Aggregate Resources Act (ARA), a process which is detailed in the Ministry of Natural Resources (MNR) Policy and Procedure Manual.

A comprehensive rehabilitation plan co-ordinates the final land use goals of several separate extraction operations into one after use plan that encompasses the total extraction area. Typically this process is too complex to be accomplished through licensing or the site plan amendment process under the ARA.

It is rare for multiple rehabilitation plans to be based on one comprehensive concept plan. It is this concept that is the focus of this study.

## 2.1 Key Considerations in Developing Comprehensive Rehabilitation Plans

The two key considerations in developing a comprehensive rehabilitation plan are timing and property ownership.

i) Timing:

Multiple sites could potentially be approved with a coordinated rehabilitation plan before the majority of approvals have occurred, as in the case of Penrith Lakes in Australia, discussed as a case study in Section 3.3. This site is extremely unusual, and involved three companies sharing resources into one operating entity in order to accomplish the combined operation.

More likely, combining rehabilitation plans may occur after operations are well underway and specific opportunities for a comprehensive rehabilitation plan arise. Examples are the Byron pits in the City of London, and the proposed Big Lake (Mill Creek) project near Aberfoyle south of Highway 401 in the Township of Puslinch.

There is the real possibility that if the process takes too long, or the benefit is recognized after extraction and rehabilitation, that it may be too late for some property/owners to be part of a comprehensive rehabilitation plan.

ii) Property Ownership

Obviously, the more owners and operators involved in extraction in a given area, the more complex any comprehensive rehabilitation plan will be to develop and implement. This is further complicated if there are public roads that traverse the licenced area. Extraction of these roads and adjacent setbacks can provide significant additional aggregate reserves, but also can have considerable public impact.

When a road is involved, the approval process is not as clear, and is dependent on the use and ownership of the road allowance and adjacent lands. There has been a historical precedent in some jurisdictions for extracting road allowances without requiring a new licensing process.

# 3.0 CASE STUDIES

In order to better understand the conditions under which comprehensive rehabilitation plans have existed, and in particular, have been successful, this study looks at three Case Studies: 2 in Ontario (Big Lake and Byron), and 1 in Australia (Penrith Lakes). Stakeholders were interviewed to get up to date information on these case studies. A list of stakeholders is found in Appendix A.

The Big Lake Concept is a proposed comprehensive rehabilitation plan for multiple pit operations currently extracting near Aberfoyle in the Township of Puslinch, County of Wellington, Ontario (see Figure 1).

The Big Lake project demonstrates a very real opportunity to combine the rehabilitation plans of several licenced operations and possible road extraction into one comprehensive rehabilitation plan. The resulting after-use would offer a significant public benefit, while allowing for additional recovery of aggregates. It is the only area in the province where this degree of collaboration is currently being considered, and it offers some helpful lessons for consideration in other locations having many contiguous operations.

### 3.1.1 Geological Setting and Aggregate Licences

The aggregate resource at this location is a provincially significant outwash deposit of sand and gravel, lying between the Galt and Paris moraines at the south end of the Township. The resource lies both above and below the water table, with the majority extending 10 metres below water in the more southerly areas. The resource now supplies 3.5 million tonnes per annum to the western Greater Toronto Area (GTA).

Extraction started in the 1960’s to build Highway 401. Three operations were licenced in 1972-1974 under the Pits and Quarries Control Act (1971). Highway 401 dissects the deposit and offers the major transportation route for shipping to the western GTA.

**Figure 1 –Big Lake Aerial Photograph**

Following an Ontario Municipal Board (OMB) Hearing in 1989-1990 that dealt with the County of Wellington Official Plan, Township of Puslinch Official Plan and three licence applications, the original licenced area was expanded significantly with the addition of three new licences south of Highway 401 (Corporation of the Township of Puslinch, 1990). Since then another three licences have been added: one north of the Highway and two to the south. Two more applications are currently in process south of the Highway. All current and proposed licences provide for extraction below the water table. The number of operations and licences are listed in Table 1.

**Table1: Summary of Mill Creek/Aberfoyle Licences**

| Proximity to Hwy 401 | # of Operations | Annual Production Million tonnes | # of Current Applications | Total Potential Operations |
|---|---|---|---|---|
| North | 4 (9 licences) | 1.5 | 0 | 4 |
| South | 5 (7 licences) | 2.0 | 2 | 7 |

Tonnages are the average of 2006, 2007 and 2008 (TOARC, per. comm., July 2009)

The four operations north of Highway 401 are close to being depleted. The original three operations are mainly used as aggregate and asphalt processing and distribution facilities. The most recently licenced operation is currently being developed for rural residential use next to the extracted lake. This development is based on a condominium plan which implements an Official Plan amendment for residential after-use approved at the time of licensing.

A Special Policy Area in The County of Wellington Official Plan specifies commercial use as the after use for the remaining three operations. Due to the presence of drumlins and moraines within this area, there is sufficient un-extracted land base beside the lakes to make these kinds of development feasible.

Unlike north of Hwy 401, there is no Special Policy Area guiding the after use for the operations south of Hwy 401. Rehabilitation is defined in the site plans approved under the ARA. The Plans generally call for the creation of lakes, with natural areas, forestry and open space, plus some development potential for residential in some cases. There will be seven lakes, separated by setbacks along property lines and Township roads.

One operation is already extracted and rehabilitated to a lake with side slopes that are graded and revegetated. The other operations are approximately half extracted, with extraction occurring both above and below the water table, with one exception where extraction to date is only above water table.

The resulting landscape is currently a series of 5 separate lakes that already illustrate a fragmented and artificial “man-made” landscape, due to the configuration of the lakes with straight edges along property lines and roads. Further extraction and the addition of another licence could potentially produce a total of 9 separate lakes totalling 700 acres. Figure 2 - Individual Rehabilitation Plans, shows the proposed after use plans of the 7 independently approved licences and one application in process.

### 3.1.2 The Big Lake Concept

The Big Lake Concept aims to create a major community asset by combining all the individual rehabilitation plans for potentially 9 lakes south of Highway 401 into one comprehensive rehabilitation plan, with one large lake, or possibly two (see Figure 3). The lakes have potential for major public recreation with options for wildlife uses as well.

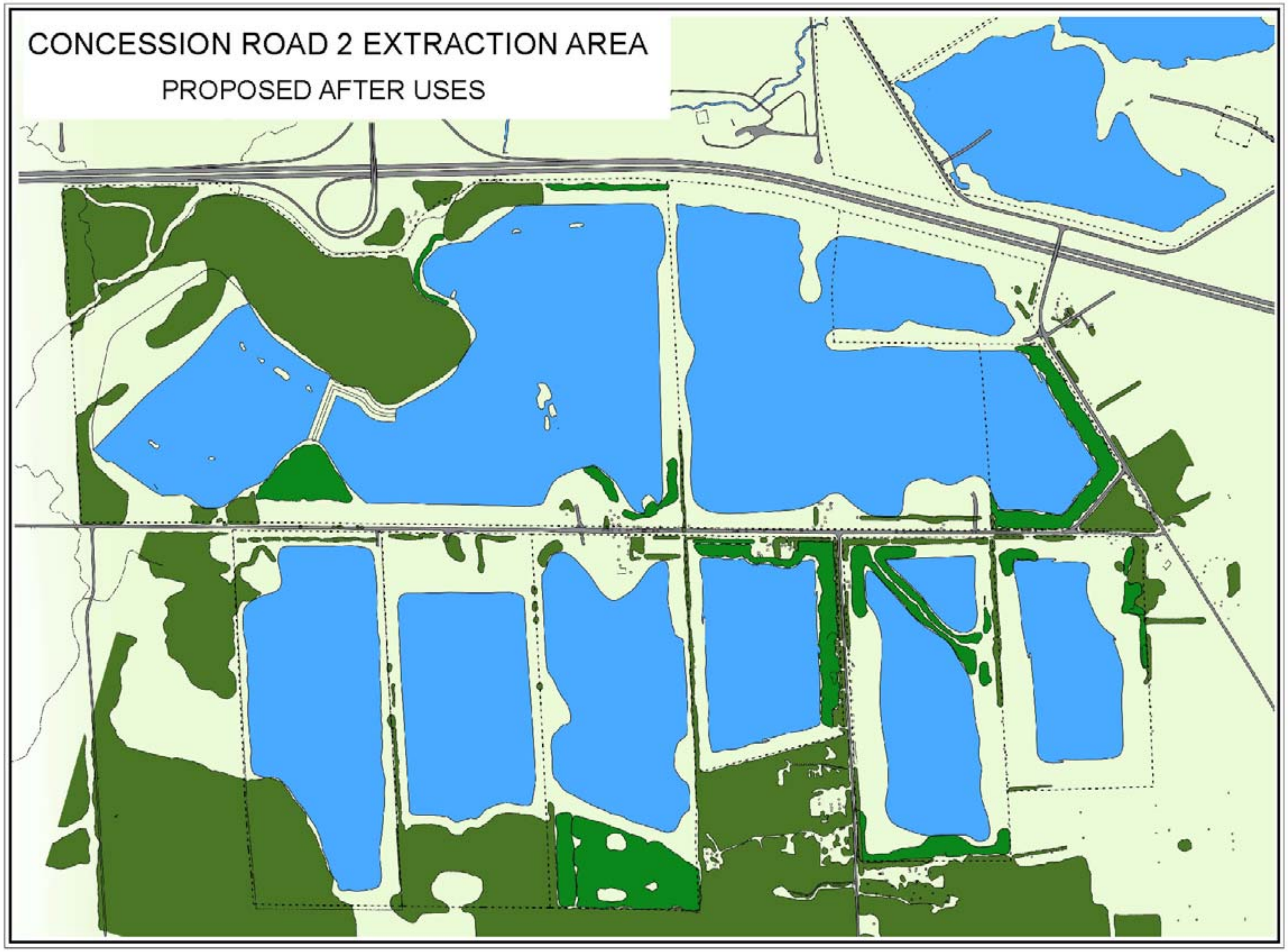
The large lake would be created by extraction of the setbacks between abutting operations and also extracting materials under two of the township roads and associated road setbacks, totalling approximately 750 acres (see Table 2).

**Table 2: Extraction and Rehabilitation potential: Big Lake Concept**

| **Current and Pending Applications** | **Area** |
|---|---|
| Licenced lands | *413 hectares (1021 acres)* |
| Current rehabilitation plans, based on 7 approved plans and 2 applications in progress | 9 lakes totalling 283 hectares (700 acres ) |
| **Proposed Big Lake Concept** | **Area** |
| Comprehensive rehabilitation plan: the Big Lake Concept | 1 (or 2) lakes totalling 303 hectares (750 acres) |
| Potential Tonnage recovered in roads, road setbacks and property setbacks | *4-8 million tonnes* |

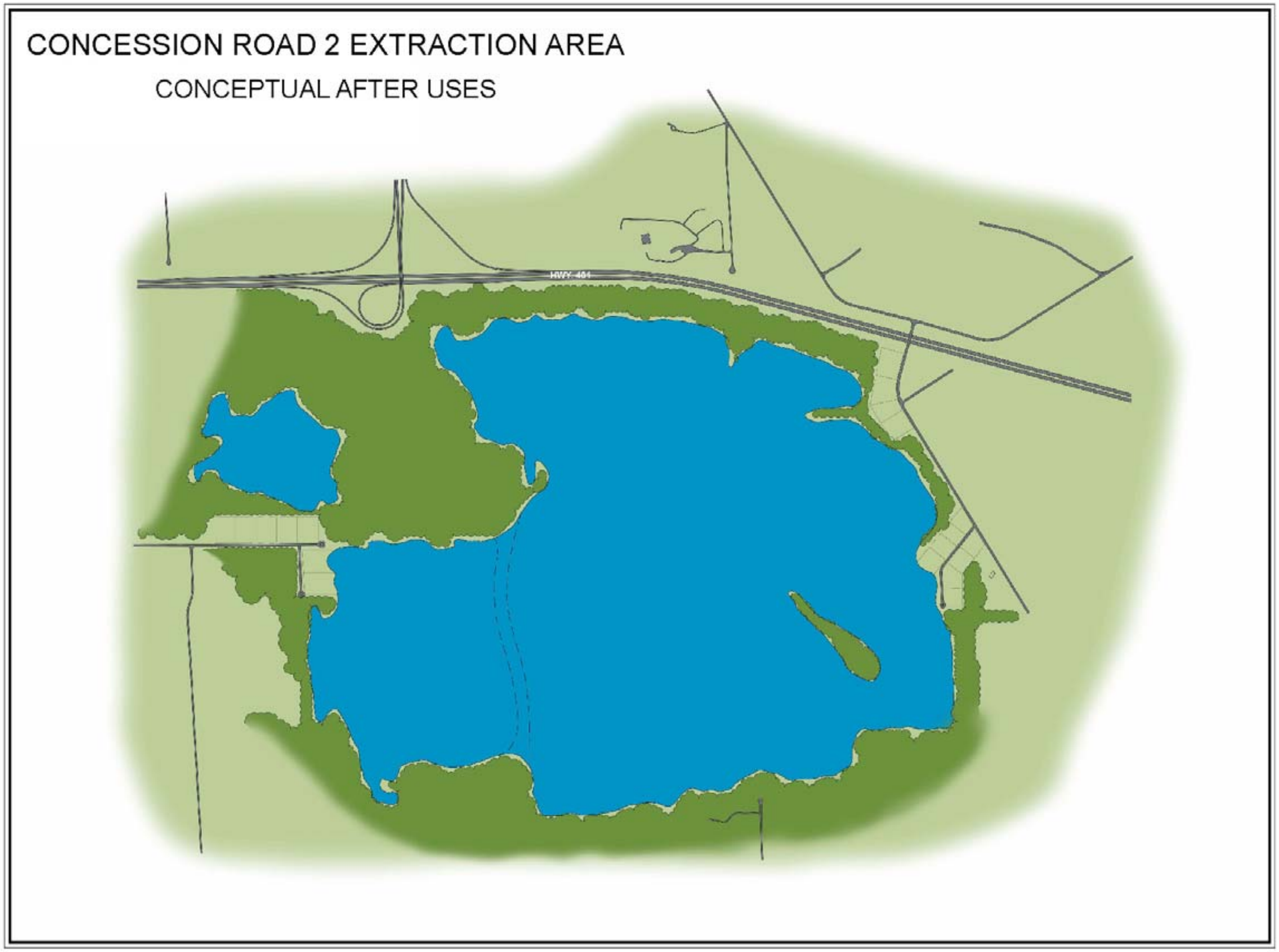
(TOARC, per. comm., 2009; Denhoed, per. comm., 2009)

**Figure 2 –Mill Creek/Aberfoyle: Individual Rehabilitation Plans (approved and in process)**




Source: Wellington County, May 2009

**Figure 3 –Proposed Big Lake: Concept**




Source: Wellington County, May 2009

### 3.1.3 Stakeholders, Process to Date and Next Steps

The Big Lake project was initiated and is still guided by the Mayor of the Township of Puslinch, with the active support of the four major landowners and operators. All of the licensees and operators agree that the resulting landscape and after-use would be a significant improvement over the currently approved lakes, and they are voluntarily pursuing the vision with the Township and other government agencies. The group to date includes approximately 20 individuals involved from the eight organizations, including their planning and technical advisors (see Table 3):

**Table 3: Stakeholders - Big Lake Project**

| Stakeholders | Role |
|---|---|
| St Mary's Cement/CBM | Landowner, licensee, operator (co-ordinator) |
| University of Guelph | Landowner, licensee |
| Lafarge | Landowner, licensee, operator |
| Dufferin Aggregates | Operator of the University of Guelph licence |
| **Government Agencies** | **Role** |
| Township of Puslinch | Lead agency plus hydrogeology |
| County of Wellington | Plan Designation and Advisor for Planning process |
| Ministry of Natural Resources (MNR) | Licensing authority, approvals for licence amendments, compliance with Aggregate Resources Act. |
| Grand River Conservation Authority (GRCA) | Key watershed mandate, Environmental review, potential public owner |

Others consulted but not currently involved as they are not active participants in this area are the Ministry of the Environment (MOE) and Hamilton Region Conservation Authority.

The Concept has been discussed over the past two years among the 8 key stakeholders. There have been meetings of all parties, plus smaller committees focussed on planning and environmental issues. It has been established that:

- the parties are willing to pursue the project further;
- the project is technically feasible, subject to a further review of the surface and ground water effects in order to ensure the protection of the Mill Creek cold water stream and associated class 1 wetlands; and
- the public needs to be consulted.

On May 9th, 2009 the project was presented in public at a Township of Puslinch Council meeting by the Township's hydrogeologist and Wellington County planner. (Corporation of the Township of Puslinch, May 6, 2009)

The next steps involve:

- Completion of agreements between producers, landowners and Puslinch Township to finalize and implement the concept;
- Establishment of a process for public/community consultation;
- Active community engagement to determine community interest in the Big Lake and associated removal of roads (public process not yet defined);
- Further technical review of the hydrogeological impacts related to the Big Lake to validate, refine or reject the concept (subject to funding);
- Implementation of any agreed-upon concept through legal agreements between the parties, planning and licence approvals/amendments for extraction and rehabilitation, planning approvals and engineering for any road closures; and
- Rezoning, licence surrender and disposition of lands when extraction and rehabilitation is complete.

### 3.1.4 Benefits of the Proposed Comprehensive Rehabilitation Plan

The two main benefits of the Big Lake are the potential public benefit of the improved lake landscape with potential public use, and the recovery of a significant quantity of aggregate resource from extraction of the roads and setbacks.

1. Public Benefit from the Improved After Use

   The proposed large lake provides a much more attractive and functional landscape than the currently approved individual lakes. Also, there is a collective vision that the lake will be available for public access and potential ownership. At 750 acres the lake is twice the size of the popular Puslinch Lake so would have considerable recreation and possibly tourism potential.

   This public benefit is the main driver for the municipality. In addition, all the landowners operators embrace "giving back to the community" as a desirable legacy.

The proposed community consultation process, when it is established, will determine if the local residents also support this concept. Still to be determined is the ultimate ownership and management.

2. Additional Recovery of Aggregates

Extraction of the 2nd Concession Road and Side Road #25, along with the setbacks to the roads and the setbacks between properties could potentially yield 4-8 million tonnes of high quality sand and gravel, from public and privately owned lands. This represents a major private and public benefit, due to the added potential value to the operators, University of Guelph and the municipality.

There is the added public benefit of recovering incremental tonnes under the existing land use; in other words, maximizing the resource at this location rather than additional greenfield land being disturbed elsewhere.

Although the vision is to extract two Township Roads, leading to one big land/lake parcel, a scaled down comprehensive plan could presumably also consider underwater extraction of just the common setbacks between licenced properties, resulting in three lakes bounded by the existing roads. Already the most recent licence has allowed for this principle, where the common setbacks held by the same owner are to be extracted, thus producing one lake from three adjacent licences. However, without the extraction of roads, both the recovery of aggregate and after-use benefit would be significantly reduced.

3. Other benefits

Other potential benefits include the possibility of increasing the after- use value for the current and adjacent owners through the improved landscape, especially if the establishment of some residential lots at the periphery are considered compatible with the overall conservation and recreation use.

The surrounding privately owned rural residential and church lands could also potentially experience an increase in property values depending on the final land use of the Big Lake and the resulting frontage onto the lake.

One possible benefit through the agency review process is the opportunity to refine some of the designs for buffers, wildlife habitat and lake edges, with possible biological benefits of the after use.

### 3.1.5 Challenges for the Comprehensive Rehabilitation plan

There are several issues to be resolved for the Big Lake Concept which will take time, money and considerable will to resolve. These are summarized in Table 4.

**Table 4: Issues to be Resolved: Big Lake Concept**

| Issue | Considerations |
|---|---|
| **Agreements between Operators/Owners** | Legal agreements are needed between operators to determine roles and cost sharing during planning, implementation and final land disposition, including logistics and potential partnering during operations and rehabilitation, environmental monitoring/mitigation. |
| **Agreements between Operators and Puslinch Township** | Legal agreements are needed with the municipality to determine logistics, timing of road closure and extraction, process for final land valuation and disposition, and aggregate allocation and valuation. |
| **Process to be determined** | The planning process still has to be finalized. It is being determined voluntarily by the willing parties, including the aggregate proponents, with no set process for a comprehensive rehabilitation plan established through the Aggregate Resource Act or current planning policy. |
| **Planning approvals** | *Before implementation*: public consultation, Class Environmental Assessment for road closure, Official Plan amendment for the proposed after-use (special policy area) , amendments to site plans and licence<br>*After completion*: licence surrender and rezoning. |
| **Final after-use** | Final land configuration and uses: recreation and conservation uses, issue of rural residential, fair share for landowners who wish to protect existing rights. |
| **Technical studies** | Groundwater/surface water modeling required to determine that Mill Creek is protected. Money will be required for studies. |
| **Public input** | Public input is desired on the final after-use and the permanent closure of roads, class environmental assessment will be required if roads are to be closed. |
| **Timing and cost** | The issues will take time and effort to resolve, and there are direct and indirect costs associated with the studies, agreements and time lines. |

1. Stakeholder interests: Agreements Between Parties

The parties are in general agreement over the vision for the project. However the stakeholders need to establish their roles and responsibilities during the approvals process and the implementation of any approved Concept Plan. There needs to be legal agreements between the parties, which involves four landowners/operators, the township and potentially the GRCA.

The benefit of the Puslinch situation is that the operators and agencies have a long standing and cooperative working relationship based on years of monitoring and collaborative environmental projects. A useful template is the Friends of Mill Creek, a group of wide-ranging parties from landowners to environmentalists and politicians, and their partner agencies, who have combined to work collectively on the single common cause of improving the health of this cold water stream. (Friends of Mill Creek, 2009)

All parties currently have the will to proceed. However, ongoing leadership is required from at least one of the proponents to champion the project. This will become increasingly challenging as the project moves forward, and the interests of all parties need to be met, including the public and political interests.

2. Planning Process and Planning Approvals

A major issue has been to establish the planning process, including the role of the public. The ARA provides for extraction of common setbacks when there are willing proponents, through the site plan amendment process. This is totally voluntary and is between the MNR and the operator, with input from the public if the MNR deems it to be a major site plan amendment. However the Big Lake project is more complicated, since there are road closures involved, and potential environmental issue associated with combining the lakes. The role of the public in this process is not clear at this point, but will likely involve a series of public meetings and possibly a community advisory committee of residents or interest groups in order to determine the community support for the Big Lake concept. Along with the class EA process, funding will be needed for a consultant to guide the public process.

There is an understanding that the Concept will be approved through an Official Plan Amendment. An amendment is subject to an appeal before the Ontario Municipal Board.

3. Finalization of End-use Concept

The Big Lake concept needs to be finalized with specific after-uses. Recreation and conservation uses with public access or ownership seem to be generally accepted as desirable, but will require refinement in order to be implemented through a combined rehabilitation plan. Also, the issue of potential residential use needs to be settled, given that the Big Lake Concept may limit the development potential. All parties, including the public, will need to buy into the after use concept.

4. Technical Studies

A specific major constraint at this site is the need for studies to assess the environmental impacts to make sure the large lake does not impact Mill Creek. This was the basic premise of the original OMB approval and is a prerequisite that all parties agree to. The operations and approved after uses are designed to protect the Mill Creek from any adverse impacts, with a very extensive monitoring program to ensure there are no effects during extraction or long term. Funding and time is needed to decide on what hydrogeology and biology research studies and monitoring are required, and to complete the work.

5. Public Input: Final End Use and Road Closures

Due to the major nature of the project, it was agreed the public will need to provide input to the final end use concept, including the permanent closure of two Township roads in order to achieve the maximum benefit of a single large lake and maximum recovery of aggregates. Additionally, extraction and closure of the roads involves a defined public process, as the roads would be closed permanently, requiring a class Environmental Assessment.

The next step in the Big Lake project is therefore a public process to determine if there is public support for the Big Lake and if the road closure negatively impacts residents' transport and the Fire Department emergency response times. If there is general support, then the class Environmental Assessment will take place. Funding will be necessary for the EA process.

Without the extraction of roads, combining the rehabilitation plans of abutting licences would be a less complicated process. This could potentially occur through a major Site Plan Amendment process, subject to an assessment of environmental impacts. Extracting the setback above water table is already provided for by Site Plan Amendments for two adjacent operations under different ownership. It has also been approved below water table, in the case of a single operator owning two adjacent licences. However, even with no roads involved, this scenario would still require agreements between landowners to resolve land ownership issues resulting from combining lake properties.

6. Timing and Cost

The Big lake project has been underway for two years and has gained a very positive outcome so far. It will be important to keep the momentum up during the next steps of public consultation and technical studies, which are expected to take another year or two at least. Due to the level of technical studies and the planning process there will be a significant cost. The Township has started investigating the possibility of support from the Province and Federal government.

## 3.2 Byron

The Byron Pits within the City of London (formerly Township of Westminster) are currently operating under an after-use concept that is embodied in the City of London Official Plan, and also a specific comprehensive rehabilitation plan that is part of the Licence and sets out the final grades for all the contiguous operations. The Plan forming part of the licence is called “Combined Progressive Rehabilitation and Final Rehabilitation Plans”. The Byron pits are shown in an air photograph - Figure 4.

The opportunity for a comprehensive plan for the Byron pits arose in the late 1980’s during a review of the City’s Official Plan policies that followed a Byron Area Study completed by the City. The goal was to reconcile the conflicting extraction and development interests in the Byron area relative to meeting the City’s need for more housing, and MNR’s mandate to protect the present and future aggregate interest for extraction.

**Figure 4 – Byron Aerial Photograph**

A Byron Feasibility Study for the after uses of the extraction operations was prepared in 1990 at the request of the City. The Terms of Reference were defined by MNR on behalf of MNR and the four operators. The Study quantified the resource, recommended where extraction and residential development could feasibly occur, where road realignment could be accommodated, and where housing was a feasible after-use, based on servicing. The necessary servicing, geology and rehabilitation studies were fairly straight forward and were completed within two years. No environmental studies were needed apart from a survey of one woodlot.

The Study proposed two concept plans and eventually resulted in a combined rehabilitation (grading) plan that is now attached as page 4 to all licences in the area east of Colonel Talbot Street (formerly North Street).

### 3.2.1 Geological Setting and Aggregate Licences

The Byron deposit is one of the deepest in the province. It is a deltaic deposit associated with the ancestral Thames River abutting the Ingersoll moraine to the south, and is approximately 60 metres deep. The gravel content increases with depth and only the lower 7-10 metres is below the water table. The Byron pits have been a steady supply of commercial grade granular products to the London area for over 70 years, averaging close to 1 million tonnes per year in recent times.

At the time of the 1990 study there were four operators with varying interests, operating five licences east and west of Colonel Talbot Street, south of Baseline Road.

Generally the landowners west of the street were developers with extraction designed to facilitate a housing after-use, while those east of the street were aggregate producers extracting under lease agreements with the landowners. Lands west of Colonel Talbot Street were close to depletion and were actively being developed for housing. Lands east of Colonel Talbot Street had 10-15 years remaining, but little progress had been made with rehabilitation due to the depth of the deposit and the unknowns as to future developments, including licence expansions, and road realignments.

Additional lands adjacent to the licences east of Colonel Talbot Street were owned by both producers and developers with interests in extraction and housing, respectively. It was in response to MNR's stated concerns about the development of these lands and the possibility of future encroachment on the existing licences (and potential new ones) that prompted the City to request the Byron Feasibility study. The objective was to delineate the limits between aggregate extraction and development, in order to reconcile the two conflicting land uses to the extent possible, and provide guidance for the City of London Official Plan land use designations and policies.

The producers were able to resolve the end uses between themselves by agreeing on the combined grading plan to suit their respective interests and also accommodate the City. However the final determination of extraction versus surrounding development had to be resolved at an OMB Hearing. These issues came before the OMB along with other Official Plan matters and a licence application in 1992. The OMB decision approved the areas for extraction and established appropriate designations, including Urban Reserve.

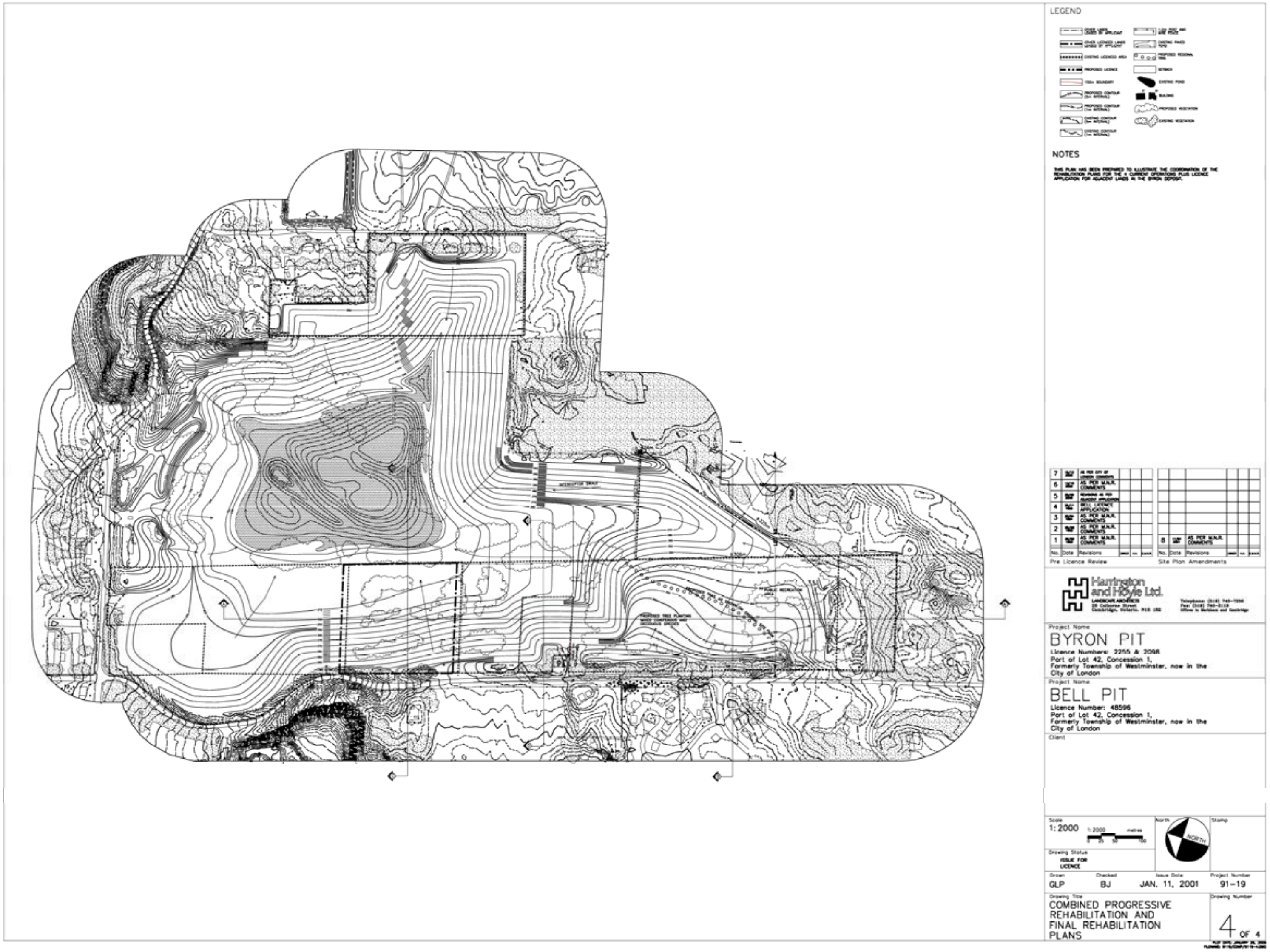
### 3.2.2 The Combined Rehabilitation Plan Concept

The Byron Feasibility Study included two after use concepts. One concept was for existing licences only. The other concept provided for additional licences and potential road realignments. It demonstrated that the expansions could also accommodate alignment of one of the roads and that residential could be a viable after use provided extraction and rehabilitation created the appropriate grades for servicing.

The plans were later refined to produce the Combined Progressive and Final Rehabilitation Plans (Combined Rehabilitation Plan) approved in the mid 1990s that harmonized the grades among abutting properties, with a land form that created stable side slopes of 2:1, pit floor elevations in some areas that would offer potential for housing as an after use, while in other areas allowed for maximum extraction and a lake after use.

Consistent with the 1992 OMB decision and City’s Official Plan, the MNR has approved five new licences with Site Plans conforming to the Combined Rehabilitation Plan, giving a total of 10 licences by the end of 1997. The current Combined Rehabilitation Plan incorporating the original three licences and five new licences is shown in Figure 5.

**Figure 5 – Combined Progressive and Final Rehabilitation Plan, Byron Pits**



### 3.2.3 Stakeholders, Process to Date and Next Steps

The original stakeholders included the City of London, Ministry of Natural Resources and the four licensees. The public participated through the normal Official Plan process. Some local residents were not in support of the combined plan, which provided for additional licences. No road realignments were included so there was no requirement for an environmental assessment.

The Combined Rehabilitation Plan was first used in the mid 1990s after the 1992 OMB Decision settled the land use schedules and policies in the City of London Official Plan. It is administered by MNR under the Aggregate Resources Act and has been updated from time to time as new licences come forward or site plans are amended. Each Site Plan Amendment is considered a major amendment, which is circulated to all parties including the City of London. If one amendment is approved, all parties amend their site plans accordingly.

Two licences in the area have recently been surrendered as of 2008. One on the west side of Colonel Talbot Street had already been rehabilitated to housing, but the City would not assume the subdivision until the licence was surrendered. The other, a more recent licence on the east side of Colonel Talbot Street, is rehabilitated to a developable grade as per the Combined Rehabilitation Plan, but development awaits the conclusion of the abutting extraction. This site is referenced in Chapter 5 – Task 2 Surrendered Licences (Site 156).

The City of London Land Use Schedule has designated the approved and potential extraction areas as Urban Reserve- Community Growth, with specific policies for the Byron pit area, including a provision that expansion may be considered, and the after use will include housing.

The Specific Policy for the Byron Gravel Pits states *"………. it is anticipated that the long term land use of this area will be a mix of medium and high density housing types and recreation uses. Redevelopment of this area will be based on a comprehensive rehabilitation and development plan………"* (City of London Official Plan, Section 9.4.6, 1992)

Assuming there are no new licences in the Byron area, the current approved Combined Rehabilitation Plan, subject to amendments, will continue as the approved rehabilitation plan for all the licences until extraction and rehabilitation is complete allowing the licences to be surrendered. The final after use will then be determined by a "Comprehensive Rehabilitation and

Development Plan" as required by the City's Official Plan and implemented by an Office Plan amendment.

### 3.2.4 Benefits of the Comprehensive Rehabilitation Plan

The Combined Rehabilitation Plan has benefits for all the stakeholders, including the landowners/ aggregate producers, City of London and public.

1. Resolution of conflicting land uses

   The plan settles where future licences and residential development would be considered, helping to resolve some of the conflicts between the two uses. Furthermore, establishing finished grades that accommodated some future residential development provided a public benefit by contributing housing supply to address the City of London's housing needs.

2. Improved rehabilitation plan and after use

   The original site plans were issued separately over the period 1972 to 1980 and the final grades were not harmonized. The combined grading plan for original and new licences offers a much more functional landscape, both in terms of the pit floor and harmonized side slopes, while maximizing resource extraction. The plan provides for the potential realignment of one of the roads (Commissioners Road) and confirms that the other will not be realigned (Colonel Talbot Street).

   Most importantly the plan includes site services and gravity feeds so that housing can be accommodated in some areas on the pit floor, when all the extraction east of Colonel Talbot Street has been concluded. Yet in other areas, the plan allows for maximum extraction, creating potential open spaces and lakes.

3. Additional recovery of aggregates

   The original site plans provided for extraction of the common setbacks, even before the Comprehensive Rehabilitation Plan was developed. However, the Plan helped facilitate five new licences issued in the 1990s, resulting in added resource recovery. Although only 14 hectares, the new licences provided over 6 million additional tonnes for extraction, a significant resource due to the depth of the deposit.

Two other benefits of the extraction at this location is the high yield of significant tonnage per hectare disturbed, compared with other shallower sources, and also the environmental and economic benefits of the area being close to the London market. All alternative sources have higher travel distances.

### 3.2.5 Challenges for the Comprehensive Rehabilitation Plan

During the approvals process the major challenge was the conflict between extraction and adjacent development, which was the main reason an Ontario Municipal Board hearing was required.

1. Stakeholder Interest

   The aggregate interests were readily resolved between the producers since the City's development pressures provided the incentive to cooperate with each other and with MNR to commission the study on aggregates extraction and rehabilitation that was required by the City. Moreover, there was no need for formal agreements among the operators since each operator supported the combined concept but could continue operating independently. Also, there was no road extraction or realignment, and no plan to convey lands to the public, so no agreements were needed between the producers and the government.

   During implementation the major challenge was and is the logistics of extraction up to common boundary lines. This is a normal issue with any common boundary extraction.

2. Planning Process and Approvals

   At this site the planning process was clear, since it was driven by the Official Plan review. The City carried out the technical studies on servicing requirements and road realignment, and conducted the public process. The MNR was engaged through their comments on the proposed Official Plan policies and facilitated the industry response. Without an Official Plan review with the incentive for MNR and the operators to resolve issues of additional licensing versus development, it is unlikely this Combined Rehabilitation Plan would have been accomplished through a major site plan amendment under the ARA.

3. <u>Timing and Cost</u>

Timelines followed the Official Plan process. Final approvals for the combined rehabilitation plan including the OMB hearing and decision were completed within five years. Due to the development and extraction issues involved the costs of an OMB were considered necessary and acceptable to the parties.

## 3.3 Penrith Lakes, Australia

The Penrith Lakes Scheme is a 2000 hectare extraction and rehabilitation project in Penrith, New South Wales, Australia. It includes a Comprehensive Rehabilitation Concept Plan approved by the State in 1986 setting out sequential rehabilitation of a major aggregate resources site for an after-use of public recreation, with provision for private urban development subject to further approvals. The rehabilitation plan is being implemented by a Corporation consisting of three aggregate company shareholders, under a 1987 agreement with the State of New South Wales. The Penrith operations are shown on Figure 6.

Extraction in the area was active in the 1950's and 1960's with three aggregate companies operating under separate approvals from the local City of Penrith. Due to concerns about piecemeal extraction and resulting limitations on rehabilitation, the City declined further individual approvals and requested that the State look at a coordinated approach to extraction and rehabilitation.

Led by the State Department of Environment and Planning, a working party developed a preliminary concept for the coordinated extraction and rehabilitation of the entire site in 1976. This plan was refined and finally approved over the next ten years, during which the following occurred: development of a single company (The Penrith Lakes Development Corporation) from the three shareholder companies (1979), a full Regional Environmental Study by the State (1984), Regional Plan approval (1986), and an Agreement between the State and the Corporation the following year (1987) for extraction and rehabilitation.

The opportunity for a high profile water facility was recognized from the outset and the agreement was amended two years later to include the Sydney International Regatta centre, and White Water stadium. These facilities helped Sydney in its successful bid for the 2000 Olympics.

**Figure 6 – Penrith Lakes Aerial Photograph**

### 3.3.1 Geological setting and Aggregate Licensing

The Clastlereigh flood plain in the western edge of the Cumberland Plain is a nearly flat alluvial terrace flanking the Nepean River, which abuts the escarpment of the Blue Mountains on the west.

The land was largely farmed before extraction. Six to eight metres of sand and gravel are overlain by six to eight metres of overburden, with shale immediately below. In New South Wales this is considered an economically viable stripping to extraction ratio.

The aggregate lies at least seasonally below the water table and is extracted dry by shovels and draglines with dewatering in cells. At the time the combined rehabilitation plan was approved (1987) it was estimated that 65 million tonnes had already been extracted, with 185 million tonnes remaining.

This aggregate resource was, and continues to be, a very significant source for the Sydney area, supplying 6 million tonnes of high quality aggregate products per year, which represents over 75% of the area's requirements. The majority of products are for concrete and asphalt. It is now estimated that the resource will be depleted in 4-6 years (2013-2015).

Before the comprehensive plan was developed there were three companies working independently in three different areas of the deposit under separate approvals from the City of Penrith. Extraction had produced lakes and settling ponds with no coordinated approach to extraction or rehabilitation. Extraction is normally regulated by the local municipality in the State of New South Wales, with approvals given on an individual basis.

Around the time the authority was transferred to the State under its Regional Plan approval process, it became clear that there would need to be a single entity operating the site. Therefore in 1980 the three companies pooled their resources and started operating as an individual Corporation that managed approvals, extraction and rehabilitation, even while they waited for the final long term approvals. These finally came in 1987.

From then until the present, the Corporation has managed a single extraction and rehabilitation operation, and has conducted all community and government relations activities, including education, aboriginal training, licensing and planning approvals, and community liaison.

### 3.3.2 The Comprehensive Rehabilitation Plan: Penrith Lakes Scheme

The Regional Plan (1986) sets the framework for design, extraction and future uses on the 2000 hectare site, following extensive analysis of possible alternatives and includes the concept plan for rehabilitation. Figure 7 shows 700 hectares of lakes and 1000 hectares of open space for a public park, and 300 hectares of urban land for potential private development, subject to further approvals.

The concept was finalized after 27 possible concepts were reviewed and reduced to three alternatives: two concepts with lakes and one with wetlands. The overriding government and public objective was for a water based recreational facility. Therefore an after use of wetlands, although having many positives including less expense, was not selected as the final use.

The final lake configuration included four lakes that suited the criteria for recreation, flooding, flood control and water quality. The lakes are being constructed with control weirs interconnecting the lakes with the adjacent Nepean river and to each other. They will eventually include the complete competitive rowing course, a warm up lake, recreation lake and wildlife lake.

The Agreement between the State and the Corporation defines the rights and responsibilities of each party including operating standards and final land disposition. There was to be an orderly sequence of extraction, with sequential rehabilitation and conveyance of the recreation based rehabilitated lands to the State.

In addition to providing for rehabilitation and after use, the Plan and Agreement require significant investment in protecting cultural heritage resources, environmental education, and providing aboriginal facilities and training.

**Figure 7 - The Penrith Lakes Scheme**

### 3.3.3 Stakeholders, process and next steps

Stakeholders include the three companies (two of which have now been purchased by two international companies), the Penrith Lakes Development Corporation, the City of Penrith and State of New South Wales. There is also a formal Community Advisory Committee (CAC) and many other interested community groups.

The International Regatta Center had been transferred to the State ownership and is managed by them. It is understood that other lands have not yet been transferred.

With only 5-7 years of extraction left, the Scheme is now undergoing review for the final rehabilitation after use. The Corporation filed a redevelopment application for the site in 2006 with some modifications to the original plan, requesting six land uses: public recreation, general residential, mixed use, recreation waterways, large lot residential and business park. There is potential for 4900 dwellings, a village, schools and community facilities. It was listed on the NSW website in 2007 as a 3 billion dollar investment proposal.

Unfortunately, the application is currently on hold, pending further review of the financial viability of the proposed land uses by the shareholder companies. According to the last published meeting of the Community Advisory Committee on May 2008, the shareholder companies are reviewing the planning constraints, which include serious considerations for flood management. In the meantime it appears that the conveyance of the lakes for a public park is also delayed.

### 3.3.4 Benefits of the Comprehensive Rehabilitation Plan

The primary benefit of the combined plan is the coordinated sequence of extraction and rehabilitation by a single entity resulting in a world class water based recreational area, while allowing for the extraction of 150 million tonnes of high quality aggregates serving the growing needs of the Sydney area. Other benefits include operation of the cultural and environmental education centres.

1. <u>Additional recovery of aggregates</u>

   The huge aggregate reserve and potential for additional recovery of aggregates offered a significant incentive to the aggregate producers, and also represents a major benefit for growth in the area. The scheme provided for the production of 25 years of high quality aggregates, at 6 million tonnes per annum from the closest source available, an extremely significant benefit for the continued development of the Sydney area.

2. Rehabilitation plan and after use

The rehabilitation plan proposes a significant recreational and tourism facility, which provided the major incentive for the local and State government and public to support the scheme.

During extraction, the single operation allows for an orderly sequence of extraction and rehabilitation which would have been impossible with three separate operations. It also allows for coordinated water management for flooding the lakes, flood control and water quality. The benefit of this was clearly demonstrated at the 2000 Summer Olympics where the world class events took place right beside the operating pit, which very few spectators would know was there.

The site has already contributed in a major way to tourism, education and aboriginal issues. The Sydney International Regatta centre is already a world class facility having hosted the Olympic Games in 2000 and continues to host world class events, with substantial tourism benefit.

The final after use will hopefully become a spectacular recreational facility in public ownership for the local, regional and international community, with significant tourism benefit to the Penrith area.

The private urban development concept was conceived as a major benefit to the operators, providing a financial return that would help compensate for the added rehabilitation costs incurred through the approved concept plan for recreational lakes. This proposed major residential and employment center, if it develops, will also have economic benefits to the local community of Penrith.

### 3.3.5 Challenges for the Comprehensive Rehabilitation Plan

1. Stakeholder Interest

   With multiple stakeholders, it is a challenge making sure all parties benefit. It took considerable effort and creativity to accomplish this between the operators, between the operators and the government, between the local and State government, and with the public interest groups.

   For example the companies had to take the unusual step of merging their aggregate and land resources to create a single operating company, the Penrith Lakes Development Corporation with four shareholders. The government had to look at the operations in a new way, as a Regional planning exercise with considerable public involvement, yet took the unusual step of not allowing third party appeals to the project.

2. Planning process and approvals

   There was a rigorous and comprehensive planning process similar to other major planning applications. It included an extensive review of the site, assessment of many alternatives, and input from the public. It required considerable time and resources. The resulting Regional Environmental Study is authored by the NSW department of Environment and Planning but it is not known who paid for this.

3. Final after-use concept

   The process for settling on the final after use included a detailed analysis of many alternatives. Settling on the final water based recreational land use with the particular land/water configuration had to satisfy many criteria. Resolving this final use was a major challenge, since the private and public stakeholders held different preferences: the operators preferred to create wetlands while the government required the more expensive recreation.

   In the end, the final incentive for the operators was negotiated to include the potential for urban development on the privately held lands.

4. Technical considerations

The environmental review identified aboriginal and cultural issues that needed to be addressed, however there were few natural environmental issues, due to the fact that the lands were primarily agricultural.

The main technical considerations at Penrith Lakes Scheme derive from the after use of public recreation, which requires the excavations to flood and hold water, the lakes to have stable banks, and the water quality to be high enough for boating. Because of the soil materials, the Nepean River and the surrounding catchment areas, this has been a significant design challenge and represents a major incremental rehabilitation cost, compared with a simpler rehabilitation alternative of creating wetlands.

5. Public input

Public input for the environmental assessment was extensive during the review, and continues to be significant during implementation with the ongoing Community Advisory Committee. Not allowing a third party challenge to the proposal removed a major hurdle that the planning process would normally include. It is assumed that the decision was based on the extensive nature of consultation, and the public benefit of the project.

6. Timing and cost

A major challenge for the Penrith Lakes Scheme has been the long time lines for the development of planning approvals and agreements - 10 years from the working party's first concept to the final approval. Fortunately the incentives were high enough that all parties considered this acceptable.

However, the long time line of extraction is an added challenge as both the company ownership and planning policies change over time. This may have contributed to the delay in the realization of the final urban after-use and also the conveyance of additional lands to the public. It is to be hoped that this gets resolved soon, since one of the incentives for the operators was the expectation of returns from future private land development and the major expectation for the public and municipality was for significant public lands for recreation.

# 4.0 OPPORTUNITIES, BENEFITS AND BARRIERS

## 4.1 Necessary Conditions for Comprehensive Site Plans

The three cases studies demonstrate that significant aggregate deposits with multiple licences offer a real opportunity for Comprehensive Rehabilitation Plans with both public and private benefits under the following circumstances/conditions:

1. There must be significant tangible incentives for all stakeholders to work on an unusual project that takes significant time and resources.

2. There must be a clear planning process that facilitates the approval and implementation of the rehabilitation concept or plan without bogging it down in red tape. Where a project is outside the scope of a Site Plan amendment process, an Official Plan amendment offers a useful planning framework for bringing together all the stakeholders provided the timelines are reasonable, the Municipality and Ministry of Natural Resources share the vision for the after use, and the Ministry of Natural Resources is fully engaged for further approvals.

3. The timing needs to be right. The best time to develop a Comprehensive Rehabilitation Plan may be when extraction is already well underway, so that the resource is understood, and end uses can be visualized, yet still with sufficient reserves available and rehabilitation not significantly completed, so that a change in extraction and rehabilitation remains feasible.

4. There must be a champion for the project that clearly sees the end goal and is willing to work with partners to reach that goal. This leader can be from municipal government, provincial government or industry. However, as there is no standard process to follow, a creative leader to develop a process, to suit the specific site is key.

## 4.2 Benefits

Comprehensive Rehabilitations Plans offer significant benefits, both to the aggregate producers/ landowners, the government and the public. They include the following:

1. The final landscape and after use value is improved. Where the final landscape is planned to include multiple licences relative to final grades and slopes, opportunities are created for a more open landscape, more variety and more connectivity. This provides a benefit whether the lands are left in private ownership or become public.

2. Resource extraction is maximized. By extracting common boundaries, road setbacks and roads, additional aggregates are recovered at the combined site. While there may need to be a balance between extraction and the final after-use landscape, the additional reserves provide the major incentive for the aggregate producers. Maximizing extraction within a licence also offers a public benefit from increasing the resource recovery at the existing location rather than a new greenfield site. The major incentive for the producers is where there is a significant tonnage of resource to be extracted, and an after use value that is enhanced.

3. Access to additional reserves may provide the opportunity for landowners/operators to consider public access or even public ownership. With the opportunity for continued extraction in an area, companies may economically be able to “give back to the community”. Additionally, a major incentive for municipalities and the public to participate in the development of a comprehensive rehabilitation plan is if there is a direct benefit from public access or ownership. All parties benefit from the enhanced public legacy.

### 4.3 Barriers to Comprehensive Rehabilitation Plans

There are not many examples of comprehensive rehabilitation plans because there are a number of barriers that limit the opportunities and benefits:

1. Lack of incentive for the stakeholders to engage in what is currently an unclear, and lengthy planning process. Without a real incentive, whether it is a better landscape, access to more reserves, public lands, or a road realignment, there is no reason for them to support a complicated and lengthy process of change.

2. There is no accepted, defined approval process, with a reasonable timetable. There are adequate planning tools within the Aggregate Resources Act and the Planning Act, but each case study illustrates a custom approach created to ensure development as agreed, over time. With a defined, clearer and more streamlined process, including the studies required and the role of the public, stakeholders could assess the timing, costs and benefits much more readily.

3. There is inconsistent support from both the MNR and municipalities. This is even relevant in the more straightforward process of extracting common licenced boundaries, and is more so when a road or allowance is involved. The former case should be a very straightforward process to maximize the resource use and improve the final landscape. In reality, it can be lengthy, and costly. It is apparent that areas having these common boundaries could be further maximized with more support from municipalities and the MNR. If a licence is required for extracting a road allowance, it would be a significant barrier to harmonizing after use plans. MNR has licenced road allowances under certain circumstances, but there has to be consistent support from MNR and the Municipality.

# 5.0 CONCLUSIONS AND RECOMMENDATIONS

Regions of the province with extensive areas of aggregate reserves are most likely to benefit from Comprehensive Rehabilitation Plans (e.g. Carden, Caledon, South Dumfries etc). Comprehensive Rehabilitation Plans would provide the opportunity to consider how best to develop and rehabilitate the resource as a whole as opposed to individual properties within the resource on a piece meal basis.

Comprehensive Rehabilitation Plans provide an opportunity to:

- maximize resource extraction within a given area;
- minimize impacts on surrounding lands;
- maximize opportunities for the final landscape form;
- maximize public engagement; and
- maximize public benefit.

These are all goals that all stakeholders should be able to support.

Chapter 6 of this report discusses recent policies that provide a basis for the development of Comprehensive Rehabilitation Plans. This trend suggests that there is provincial support for Comprehensive Rehabilitation Plans and as a result, there may be increasing opportunities for their development.

The following recommendations are intended to increase opportunities for successful development of Comprehensive Rehabilitation Plans.

1. Municipal and Land Use plans ( such as Official Plans, the ORM Plan and NEP) with large resource areas to give consideration to the preferred after uses, including the designation of after uses and definition of special policy areas, during the routine process of Plan updates. This would be in addition to the licensee's requirement under the ARA to identify the proposed final land use, and could assist in establishing goals.

2. Municipalities, through updates of their zoning by-law, to include a clause which provides for side and rear yard setbacks to be automatically reduced to zero along a common licenced boundary.

3. Municipal Official Plans, during the routine process of Plan updates, to have policy to encourage extraction of common setbacks between licences.

4. Planning for “greenfield” areas as defined by the Growth Plan for the Greater Golden Horseshoe under the Places to Grow Act should include consideration for Comprehensive Rehabilitation Plans.

5. Ministry of Natural Resources develop a Policy and Procedure to encourage the harmonization of two or more adjacent operations through the mutual extraction of common boundary setbacks and creation of a common after use plan, under the site plan amendment process

6. Where multiple sites exist abutting one another, especially adjacent to a road allowance, MNR and the municipality should attempt to find a common approvals process. The producers will have access to additional reserves, so they should be interested in participating, recognizing it is a ‘give and take’ process.

7. Provide an opportunity for public engagement. Once the public realizes they can be a part of something that will change the landscape to meet their goals, they may be willing to participate. The municipality and MNR should be promoting and supporting these initiatives, as they implement provincial policy (PPS).

8. Comprehensive Rehabilitation Plans should be considered as early as possible. Once in place, they provide certainty to both producers and local residents. This could help reduce the tensions that have increased around applications.

Appendix A

Stakeholder Contacts for Comprehensive Rehabilitation Plans

| **Agency** | **Stakeholder** |
|---|---|
| MNR Guelph | Mike Stone<br>Al Murray<br>James Williams |
| Township of Puslinch | Mayor Brad Whitcombe,<br>Stan Denhoed, |
| County of Wellington | Gary Cousins,<br>Aldo Salis |
| University of Guelph | Nancy Sullivan<br>Philip Wong<br>Sandy McLellan |
| CBM | Melanie Horton |
| Dufferin Aggregates | Kevin Mitchell<br>Ron Van Ooteghem |
| Lafarge | Chris McGuckin |
| Consultant | Glenn Harrington |
| MNR Aylmer | Stephen Douglas |
| Lafarge | Chris McCuckin |
| City of London | Heather McNeely |

# CHAPTER 9

# SAROS PAPER 6 REHABILITATION

# REHABILITATION TECHNOLOGIES AND APPLICATIONS

# A GLOBAL SCAN

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## TABLE OF CONTENTS

## 1.0 INTRODUCTION

Task 8 was focused on providing a "*global scan of rehabilitation technologies and applications used in other jurisdictions including passive rehabilitation technologies*".

Many factors come into play when deciding upon a particular approach or protocol to follow in the rehabilitation of aggregate extraction sites in Ontario. Understanding the wealth of different approaches taken within other geographical jurisdictions, including the rationale underlying such approaches and the likelihood of their success, can provide helpful guidance. To enhance this understanding, a global scan of rehabilitation technologies and applications employed around the world principally in aggregate pits and quarries was undertaken. References to other mines were made where important lessons could be drawn and related to the aggregate industry and associated rehabilitation.

To maximize the scientific validity of the results of this scan our attention was focused on records of scientific research related to sites in the peer-reviewed science and engineering literature. The Thomson ISI Web of Knowledge databases were used to search for the terms ["quarry or quarries" OR "gravel pit*"] for all years available then refined the search to include only records in the subject areas of environmental science and ecology. The 1609 records resulting from this search were parsed through manually to eliminate those with little apparent relevance. Additional papers cited within the collected references but not detected by the initial search were also gathered. The outcome of this exhaustive search is a bibliography consisting of 514 peer-reviewed articles with relevance to site rehabilitation or after-use.

This literature was organized first according to whether insight was provided into: (1) processes of passive rehabilitation, whereby rehabilitation occurs spontaneously with little human design or input, or (2) processes of active rehabilitation, where humans (e.g. the operator) play an active role in determining the final outcome. The literature on active rehabilitation was then analyzed with respect to contributions to understanding or improving upon several key steps common to most rehabilitation projects at extraction sites:

1. pre-planning and design;
2. shaping of the landscape;
3. control of drainage and groundwater relations;

4. development of soils;
5. introduction of vegetation;
6. improvement of habitat for wildlife and other organisms; and
7. long-term maintenance or after-care of rehabilitated sites.

Within each step a variety of end-uses are considered, from creation of natural heritage ecosystems to ecosystems suitable for agriculture, forestry, recreation, or further industrial usages. The results of our scan present a picture that is truly global, with evidence presented from six continents and many countries. Here we discuss those examples most relevant to assisting managers of aggregate extraction sites in Ontario in making decisions with respect to strategies, technologies, and applications that may be employed in rehabilitation; however, the broader bibliography is presented as an appendix to this document.

# 2.0 APPROACHES TO REHABILITATION

## 2.1 Passive Rehabilitation

Forty-five percent of the pit and quarry rehabilitation bibliography (222 papers) reported research related to the spontaneous revegetation of abandoned extraction sites. This predominant focus on natural regeneration is understandable in light of the fact that such sites have long been used by ecologists to study successional processes in ecosystems, and have often been noted by naturalists as outstanding sites for the observation of rare flora and fauna. Professional ecologists are perhaps more likely to devote necessary time and research effort to meet the high-standard of peer reviewed publications, as opposed to industry publications where the focus of research might be more directed towards practical applications (i.e., not research-based).

Many of the records discovered in our global scan consist of reports by naturalists regarding the occurrence of biota in dry and flooded sand pits, gravel pits, limestone quarries, and other open-cast mines, where minerals had been removed primarily to obtain construction materials. However, across this same range of papers, many dealt with the concepts of community assembly or ecosystem development over time, including efforts to determine controls of the different courses that such succession can take and suggestions for how knowledge of processes may be applied to landscape rehabilitation and management.

A similarly large number of papers dealt with the idea that the extracted sites provided refuge to particular species or communities of conservation concern, even without any active rehabilitation, again with the suggestion that promoting or at least not hindering natural processes could function powerfully to increase the biodiversity of landscapes and should be incorporated into management plans. Authors generally acknowledged that their studies of succession took advantage of cases where active rehabilitation was not pursued; they were not arguing that rehabilitation should never be pursued however, an emerging theme of the literature is that natural forces of regeneration on their own can often be a powerful tool. As such, managers would be wise to work with rather than against such natural processes (Bradshaw 1997).

The case for working with natural regeneration processes can be made through observations of the natural occurrence of conservation priority species at particular locations, and from carefully conducted studies aimed at identifying general patterns and mechanisms of revegetation. Analysis of spontaneous revegetation at 10 open-cast lignite mines in Germany and species composition in surrounding areas up to 17 km away, for example, highlights the importance of the regional species pool in determining plant community assembly at damaged sites. More than any other factor, the presence and abundance of species in the surrounding landscape influences the probability of colonization at mined sites (Kirmer et al. 2008). Investigation of spontaneous succession at gravel pits (Rehounkova & Prach 2008) and basalt quarries (Novak & Konvicka 2006) in the Czech Republic, and at gravel pits in Sweden (Borgegard 1990), to varying extents support this conclusion.

While not surprising in some senses, the idea that succession depends on a "random lottery" process of propagule immigration stands in contrast to the long-held idea in ecology that succession is an orderly progression, driven strongly by species-specific properties such as dispersal capacity and evolved tolerance to harsh environments (Clements 1936). However, in both the case of lignite mines and that of gravel pits, some species-specific traits were found to be important, above and beyond spatial mass effects. For example, species with seeds adapted for long-range dispersal were found at lignite mine sites more often than expected given their abundance in the environment. Similar patterns are evident for species with nutrient and light requirements consistent with open, infertile soils. Many such species are relatively rare in the landscape but established preferentially under mined-site conditions when "caught" by sites serving as giant seed traps. As a result, nationally-threatened species colonized mine sites successfully on 143 occasions, many immigrating from more than 10 km away. In the gravel pits examined in those papers, surrounding semi-natural vegetation was certainly important, but different environmental conditions within sites clearly filtered the regional species pool and enabled only a subset of immigrating species to establish (Kirmer et al. 2008; Rehounkova & Prach 2008).

Not many studies have gone to the effort of cataloguing species within both extraction sites and the surrounding landscape, a necessity if the importance of regional species pools is to be tested. There are, however, many studies of mined sites alone that strongly support the idea that site-specific environmental conditions contribute importantly to biodiversity establishment and ecosystem development. Analysis of abandoned limestone quarry floors in Ontario revealed that while harsh site conditions appear to have prevented colonization by common species in the surrounding landscape, species characteristic of geographically distant but ecologically analogous natural limestone pavements (alvars) can thrive on the quarry surface (Browning 1998; Tomlinson et al. 2008). The success of alvar species on quarry floors is likely an outcome of the long-term evolutionary adaptation of these species to stressors in their natural environment that are identical to the forces preventing local species from establishing on quarry floors: scarce, nutrient-poor soil, intense heat and drought stress, and regular disturbance by flooding (Richardson et al. 2009). Similarly, exposed cliff faces created during quarrying in Ontario, revegetate slowly and support only a subset of the species pool inevitably immigrating to cliff microsites; namely, those adapted to extreme physical conditions occurring on natural cliff faces of the Niagara Escarpment (Ursic et al. 1997).

Additional evidence for the capacity of mined sites to accommodate diverse species assemblages characteristic of valued natural areas come from investigations of limestone quarry floors in Lebanon (Khater et al. 2003), quarry cliff faces in China (Yuan et al. 2006), gypsum quarries in Spain (Mota et al. 2003), and gravel pits in Poland (Bzdon 2008). High conservation values have long been attributed to abandoned chalk quarries in the United Kingdom (Ratcliffe 1974; Usher 1979; Jefferson 1984). These studies independently conclude that species demonstrating high success during spontaneous succession should be considered for introduction should active rehabilitation ever be undertaken, as opposed to species that may have existed on-site historically, but under dramatically different environmental conditions.

The contrasting nature of environmental conditions at a site before versus after extraction is perhaps most evident in the increasing number of cases where mining occurs below the water table and where terrestrial sites give rise to partially or wholly aquatic environments. Such processes combined with spontaneous regeneration have led to diverse grasslands, forests, or mineral outcrops becoming replaced by diverse quarry wetlands in Illinois (Anderson & Brown 1991), and species-rich gravel pit lakes in Germany (Neumann et al. 1994; Paetzold 2003) and Slovakia (Otahelova & Otahel 2006), for example. For wetlands to develop on their own, the water depth is critical, so that the naturally shallow extraction in many UK river based sites is well suited for natural development of wetland habitats. In contrast, sites where extraction is deeper require specific edge or island design or active water management to provide the required landscape.

Examples of abandoned extraction sites spontaneously providing refuge to particular species or taxonomic groups of high conservation importance, as opposed to whole communities, are abundant in the surveyed literature. In the UK the rare aquatic plant Water Germander has recently been discovered to be “back from the brink of extinction” thanks to a flooded limestone quarry (Beecroft et al. 2007). The similarly rare but terrestrial plant Lakeside Daisy, an alvar endemic, has found important refuge at the Marblehead Quarry in Ohio (Hannes & Hannes 1984), while the rare Northern Oak Fern has been located at a quarry in Sweden (Wiren 2007). Threatened orchid species have successfully colonized flooded portions of lignite mines in Germany (Esfeld et al. 2008). While their conservation is often attributed less importance than many other taxa, it should not be ignored that abandoned extraction sites around the world have been noted for uncommon and diverse moss, lichen, and fungal communities (Godfrey & Mehdi 1982; Janssens & Baker 1984; Buryova & Hradilek 2006; Thiel & Spribille 2007; Chen et al. 2008).

Rare species of early-successional spiders have been noted in piedmont quarries of the Czech Republic (Tropek & Konvicka 2008), while conservation-priority ant species have found important refuge in Belgian quarries (Wouter et al. 2009). Worldwide, quarries provide important habitat to declining pollinator species such as bees (Ancona et al. 1994; Archer 1997, 2003, 2006), and interestingly both young and long-abandoned sites are important in this regard (Krauss et al. 2009). Environmentally heterogeneous limestone quarries in the Czech Republic have become colonized by diverse and important butterfly species characteristic of a variety of habitat types, including both early-successional xeric conditions, and later-successional scrub conditions (Benes et al. 2003). Interestingly, still-active quarries were as important as abandoned sites in providing butterfly habitat. Flooded sand and gravel pits in Belgium, Germany, Luxembourg, and Switzerland have become noted habitats and breeding grounds for numerous dragonfly species, including many that are rare or endangered (Wildermuth & Krebs 1983; Trockur 1997; Percsy & Percsy 2008).

Pit or quarry lakes and wetlands have frequently been noted as important habitat for waterfowl, particularly in England (Phillips 1992; Kirby et al. 1994), France (Santoul et al. 2004; Frochot et al. 2008), and the United States (Hickman 1994), including threatened species such as the Great Cormorant, Little Grebe, and Mute Swan. Quarry cliff faces have been discovered to provide ideal habitat for Peregrine Falcon eyries in diverse regions including Australia (White et al. 1988; Emison et al. 1997), Ireland (Moore et al. 1997), Germany (Heller 1992), and Alaska (Ritchie et al. 1998). Least Terns and Piping Plovers have found prime nesting and foraging habitat at recently abandoned sand pits in Nebraska (Sidle & Kirsch 1993; Wilson et al. 1993), while spoil mounds at European sand and gravel pits have provided excellent nesting conditions for burrowing birds such as the Sand Martin (Jones 1987; Walter & Pudimat 1999).

Quarry caves in several European countries provide important refuge habitat for rare and diverse bat species, as the high and constant temperatures at such sites are ideal for bat hibernation (Lina 1993; Hanzal & Prucha 1996; Kliesch et al. 1997; Weinreich 2007). Moist areas of pits and quarries in Europe are noted habitat for a large variety of reptiles and amphibians (Holman 1985; Sinsch 1988; Ancona et al. 1995; van den Broek & Tilmans 2004).

Fewer records of larger animals at abandoned pit and quarry sites exist than for most other taxa, but even so, several examples suggest species ranging from rodents in Africa (Chidumayo 1980) to rabbits, foxes, opossums and deer in the USA (Rosiere et al. 1989) find valuable habitat at such sites. Some 527 species of animals within eight major groups (birds, amphibians, bees, wasps, butterflies, grasshoppers, carabid beetles, and dragonflies) were observed at a single gravel pit in Germany, and 216 of these are considered endangered (Schiel & Rademacher 2008). In general, such case studies make a strong argument for the conservation of abandoned sites as they exist prior to reclamation: they can evolve naturally into important refugia for very diverse species assemblages of high conservation value.

While the case for passive rehabilitation via spontaneous regeneration from native on-site soils or from surrounding seed sources is a strong one, in many situations it is impractical given the length of time required. For example, in the absence of active rehabilitation, dry sand or gravel pits may take anywhere from 20-30 years (Rehounkova & Prach 2008) before they support ecosystems that meet management goals. Such goals might include establishment of particular species or levels of biodiversity, particular levels of vegetation cover or ecosystem process rates, consistent with or complementary to surrounding land uses, aesthetics, or public approval.

Dry quarry floors, exposed cliff faces, and other extreme-stress sites with scarce, infertile, or contaminated substrates for plant growth may take much longer to recover naturally; in many cases, from 70 to more than 100 years (Ash et al. 1994; Ursic et al. 1997; Cullen et al. 1998; Dana & Mota 2006). While reservation of some such sites as preserves for the slow process of primary succession has frequently been argued for (see above), clearly in many cases managers are interested in or are driven to accelerate the pace of regeneration through active participation in the rehabilitation process. Indeed, governing policies often demand this (ARA 1990). At this point concepts of pre-planning and design in rehabilitation become crucial to the long-term success of the project.

## 2.2 Pre-planning and Design in Active Rehabilitation

Pre-planning is a critical aspect of active rehabilitation, where planning the desired after-use and the extraction and rehabilitation methods to achieve it can result in the most effective and successful outcomes. In general, active rehabilitation is most successful when goals and methods are decided upon before resource extraction begins, such that extraction practices and rehabilitation methods can be harmonized to optimize efficiencies. Planning the removal, effective storage, and replacement of soils in a manner that complements the process of extraction exemplifies this (Zimmerman et al. 1998; Herath et al. 2008). However, pre-planning and design can occur at several levels, from choosing which type of visual landform is most desired, to constructing design drawings for geotechnical stability (i.e. low erosion or risk of rock-slides). Initial design has powerful implications for all subsequent steps in the rehabilitation process, including drainage, soils, plantings, and after-care, although it does not necessarily follow that any rehabilitation will unfold exactly as planned.

Further pre-planning at the landscape level is required in regions such as Israel, where demand for land is very high and the most efficient use for disused extraction sites must be weighed carefully (Milgrom 2008). There, the problem of deciding whether a given site should be directed towards "open space" uses such as agriculture, natural heritage, and recreation, or "development" uses such as construction of industrial plants and residential buildings, was approached through the use of Geographical Information Systems (GIS). A well-resolved database of the full suite of different land uses in the country was created, and locations of particular quarry sites scheduled to undergo rehabilitation were cross-checked with surrounding land uses. Calculations enabled a determination of whether any given site was more suitable as an "open space" or "development" location based on the distribution of similar land uses in the surrounding regions.

Similarly, careful planning and design led to the effective rehabilitation of a large gravel pit on the outskirts of Stockholm, Sweden (Morfeldt 1993). In that case there was a desire to recreate landscape features of high cultural and ecological value in Scandinavia called eskers, which are long, winding ridges of glacially deposited gravel and other sediments. One esker had been mined-out long ago in the construction and expansion of Stockholm, but an opportunity to fabricate a new esker and to rehabilitate the gravel pit was presented when many of the city's older buildings underwent demolition prior to replacement by more stable structures. Demolition created mass waste materials that on one hand represented a potentially expensive management problem for Stockholm, but on the other hand represented aggregates mined from the original esker. The City enabled the disposal of the demolition wastes to the gravel pit, while the rehabilitation design made effective use of this material in the construction of a new esker. Such creativity and opportunism in project planning can contribute to effective rehabilitation, in some cases solving multiple challenges or goals with one action. This example assumes, of course, that these waste materials were recycled to the extent feasible at the time given available technologies.

Design and planning at the level of landscape architecture and geological engineering was fairly well documented in the surveyed literature. There is a general divide between plans with a focus on minimizing off-site effects – for example, shaping slope topography to minimize sediment erosion and run-off to downstream ecosystems – and plans to create healthy ecosystems for conservation of natural heritage, ecological functions, or other particular land uses on-site (Nicolau 2003). In the former categories, professionals determine landform results with the greatest geotechnical stability and lowest erosion from exposed slopes and banks. Equations and simulation models can be used to determine optimal designs for slopes, catchment basins, floodplains, ditches, and rivulets. However, those structures found to be most stable geotechnically, such as the platform-bank model, are unfortunately often incompatible with establishment of ecosystems that are healthy and stable in the ecological sense (Nicolau 2003).

In the case of natural heritage after uses, the choice of a rehabilitation end land use target can be the most important factor in contributing to rehabilitation success (Hobbs 2007). It is important to recognize however that the decision itself is only partially influenced by environmental sciences such as ecology and geology. Human values ranging from aesthetics to corporate interests, recreational requirements, and cultural attachment to natural heritage features can easily play a role of equal or greater importance in selecting an ecosystem target (Davis & Slobodkin 2004; Hobbs 2004).

In certain social, cultural, and environmental contexts, some ecological goals are more practical or likely to succeed than others (Choi 2004 - see Task 4). Additionally, practical tools have been developed to help managers predict and weigh the different potential outcomes of choosing different restoration targets. These range from computer programs that create visual representations of different successional trajectories based on the similarity of site conditions to previously-studied sites (Corry et al. 2008), to databases that will produce lists of species with high potential to colonize successfully particular sets of initial site conditions (Brewer & Menzel 2008; Brudvig & Mabry 2008).

One common theme from the literature on spontaneous regeneration is that the progression of species naturally colonizing abandoned sites over time highlights species with high colonization potential (Duan et al. 2008; Rehounkova & Prach 2008; Tomlinson et al. 2008). Thus, the process of natural colonization may be hastened by planting species that would thrive on the sites naturally (Ash et al. 1994; Richardson et al. 2009). Choosing such target species and environmental conditions at the outset of the extraction operation rather than after extraction can provide the necessary time to secure resource allocations and often difficult to acquire materials, which will lead to more effective and efficient rehabilitation.

Relief designs can be based on the idea that geological evolution is an important natural process that should be encouraged. The rehabilitation of a silica sand quarry on the Spanish Iberian Peninsula has demonstrated the utility of this approach, where the first step of rehabilitation was to take careful account of the origin and evolution of landforms in the surrounding area, including dividing the region into geomorphological units and making precise slope profiles (Duque et al. 1998). New slope profiles for the mined areas were then designed that would mimic not only the geomorphology of the surrounding area, but also the dynamics of this morphology over time. Features such as the convex-straight-concave "equilibrium morphology" of slopes, and the shaping of natural-looking trenches at the feet of slopes, successfully controlled both runoff and the evolution of gravitational processes. In fact, the design used actually promoted soil accretion and spontaneous revegetation over time, while simultaneously making efficient use of the scant extraction spoils available to reshape slopes.

## 2.3 Land Formatting: Shaping the Landscape to Resemble Target Landforms

In most cases the rehabilitated land forms are designed to facilitate the desired after uses. Landforms may include specific desirable physical landscape features (e.g., eskers in Sweden, or cliffs in the Peak district in the UK, or escarpment in the Niagara Region) or may be designed merely to blend in with the surrounding landscape. They may be specifically crafted, to provide appropriate wildlife habitat, or simply produce a safe and stable environment.

Earthmoving and reconstruction is carried out by way of heavy construction equipment and in some cases with specialized blasting techniques. In projects where public safety and geotechnical stability are the highest priority and often mandated so by statute (ARA 1990), quarry faces are backfilled, and graded to maintain a slope of at least 2 horizontal metres for each vertical metre (i.e. a 2:1 slope). Construction equipment including dozers, graders, scrapers, excavators, compactors, and moisture ploughs carry out these operations, with much modern equipment guided by highly accurate laser and Global Positioning Systems (GPS).

Although they are safe, uniform slopes are very homogeneous and can lead to low biological diversity (Yundt & Lowe 2002). An alternative approach was developed in the United Kingdom, where limestone quarrying was carried out in mountain valleys or dalesides of high scenic beauty as well as cultural and ecological importance. Rather than construct uniform slopes, land managers wanted to replicate important natural features of the daleside including slopes of variable steepness and exposed rock faces. This goal of "landform replication" was approached using experimental blasting techniques ("restoration blasting") and initial results seemed positive: blasted sites supported diverse calcareous grassland flora and fauna as a result of both spontaneous revegetation and the addition of topsoil and seeds of daleside species (Gunn & Bailey 1993; Wheater & Cullen 1997; Cullen et al. 1998). However, later inspections of the "restored" UK sites revealed that they had very low geotechnical stability, so low as to be considered unsafe for most typical after-uses (Cripps et al. 2002). A separate attempt to apply restoration blasting to landform replication in Hong Kong was deemed largely a failure due to physical and chemical problems in the resulting substrates. These included high stone content, coarse texture, limited moisture storage, lack of nitrogen and phosphorus, and low cation exchange capacity (Jim 2001).

The Shek O Quarry site in Hong Kong expanded the quarry boundary in order to reduce the overall slope angle and to ensure geotechnical stability. This approach also ensured a final profile that was better suited to maximizing vegetation growth, and allowed for better integration into the surrounding landscape. Blasting and earthmoving were employed in the task of reducing the slope of the quarry faces to 35 degrees – still relatively steep, but in keeping with the surrounding landscapes. Stream channels were cut into the site's slopes and linked with the drainage hydrology to provide various functionally important habitat features. Similarly, vegetated scree slopes were created throughout the site using shot rock material held down by a geo-textile fabric overlay. A mantle of 60 to 80 cm of compacted topsoil was applied above the fabric, followed by hydroseeding and placement of an erosion mat. Fast-growing, non-native grass species were seeded to slopes to obtain quick cover and increase soil stability, but slower-growing native species were also sown, to establish under the protection of the faster-growing exotics. Both native and non-native tree and shrub species were planted into water-drenched holes dug into prepared compacted soil slope surfaces. Fire-resistant Acacia trees were planted in 20 m wide belts as firebreaks. A novel additional step in the rehabilitation was the hollowing-out of cavities in rock faces to encourage nesting by Peregrine falcons (Janet Forbes, Personal Communication, Ecology Consultant, McCarthy Forbes, August 7, 2009).

Application of normal production blasting, earthmoving, and naturalization to landform replication of exposed cliff faces and "talus" slopes in the Niagara Escarpment region of Ontario have proven somewhat more successful (Zimmerman & Lowe 2001). Slope construction below the quarry cliffs included placement of soil materials rather than shot rock, and although consisting mostly of overburden soils capped with native topsoil, some areas included the use of quarry pond fines in slope construction, which were carefully tested and found to be sufficiently stable when engineered (Fraser & McBride 2000).

In scenic mountainous regions of the UK and the US, rehabilitation attempts focused on making the quarry site blend into the surrounding landscape by the construction and vegetation of quarry benches. One such approach in the UK is called the "rollover concept". With this technique backfill is applied to the lip and upper terraces of the quarry pit, from which hills with contours consistent with the natural mountainside are sculpted, such that the pit itself is mostly invisible from a moderate distance away (Yundt & Lowe 2002).

In the Boulannais Region of France, hard limestone is extracted from five quarries, but for every two tonnes of aggregate that is extracted, one tonne of overburden must be removed and stored. To accommodate this extensive amount of material, a 30 year landscape plan was completed and based on local topography, landscape architects proposed the creation of artificial hills constructed to mimic those of surrounding natural features. This approach allowed for better integration into the surrounding landscape and the artificial hills have also been planted with trees (Moreen Miller, pers. comm., July 27, 2009).

Where aggregate mining proceeds below the water table land-shaping can actively involve the creation of ponds, lakes, and networks of connected water bodies for residential, recreational, and natural heritage purposes, either through normal extraction equipment during mining operations, or through use of traditional earthmoving equipment (Roelle & Gladwin 1999; Indermuhle & Oertli 2006; Calle et al. 2007). At an old quarry in Ontario featuring a deep lake and steep cliff faces, blasting and heavy construction equipment was used to collapse the cliff into the lake and reshape the area into a series of shallow pools to be colonized by calcareous fen species (Duval et al. 2007). In coastal regions such as the shores of the Baltic Sea quarrying is performed by dredging the seafloor, in which case rehabilitation can involve partial refilling, shaping, and monitoring of submerged pits (Szymelfenig et al. 2006; Kubicki et al. 2007).

At smaller spatial scales on terrestrial sites, earthmoving and topographical engineering of extraction surfaces may be important for creating both microhabitat conditions required by particular organism, and habitat heterogeneity important to the maintenance of diverse biotic communities. Experimental assessment of the utility of such approaches has been rare but examples include hand raking and shovelling of gravel pockets and mounds to create microsite relief in gravel pits in Manitoba (Rausch & Kershaw 2007; Trimble and Seibert 2002). Application of the 'pit and mound' technique at various sites in Ontario, including Clear Creek Forest, has proven to be very successful in mimicking the natural micro-topography of older growth forests and in increasing infiltration (Figure 1; NCC 2009). Figure 2 demonstrates the effectiveness of this approach in retaining water for longer periods of time and, by extension, creating habitat for amphibians and other wildlife and also increasing water retention and groundwater recharge.

Further experimentation with this specific technique is being applied at various pits in Ontario including the Sorensen pit north of Napanee and at Task 1 - Site 120.

**Figure 2 - Water-Filled Pit: Clear Creek Forest (Credit: Nature Conservancy of Canada)**

Employing hand-held rock hammers to create cracks, fractures and divots in Ontario limestone quarry floors prior to addition of alvar species (Stabler 2009); and pneumatically drilling holes (20 cm x 20 cm x 30 cm deep) into Chinese granite quarry cliff faces prior to addition of native climbing species (Wang et al. 2009) are all approaches that have proved successful in promoting vegetation establishment despite harsh environmental conditions.

For agriculture, uniform landforms with level or gentle slopes are usually preferred, and in the case of tender fruit in California and Ontario, exacting grades to ensure proper air drainage and no frost pockets is essential (Lowe 1979). The management of localized conditions of temperature and humidity are important considerations with various crops. These conditions vary from just above the canopy to below the soil surface, with the vertical transect forming the "microclimatic profile" of the system. Through appropriate design and management, the microclimate of a system can be modified with the focus often being specifically on temperature. Examples of modifications to the microclimate include changes in canopy vegetation, such as planting trees or installing artificial canopies (e.g nylon fibre), will serve to modify the temperature, while shading the soil with a cover crop or mulching can influence changes in soil temperature microclimate. Changing the colour of the soil surface by altering its albedo through practices such as burning crop residue so that the carbon absorbs a greater amount of heat will also serve to modify the soil temperature (Gliessman 2000).

In India, the general approach to aggregate extraction is to focus on the removal of ‘knobs’ (hills) so that the vast majority of after uses are agricultural on the resulting flattened landscape (Moreen Miller, pers. comm., July 27, 2009).

## 2.4 Drainage and Groundwater Protection

Principles of hydrology and hydrogeology are critical to both the excavation and the rehabilitation of aggregate extraction sites. Three key areas of interest with respect to rehabilitation are:

1) Controlling water drainage to maximize the integrity of ecosystems developing on-site and those existing off-site,

2) Identifying groundwater levels and surface groundwater interactions in the rehabilitated landform critical for the desired after use, and

3) Protecting groundwater resources from limited potential risks of contamination associated with the storage of chemicals and fuels used in operations.

Technologies and applications relevant to the first two concerns are primarily employed during rehabilitation steps already discussed here: site design and land shaping. For example, in agriculture, forestry, and some target natural ecosystems, providing an appropriately well-drained site is essential. Depending on the soils substrate and levels of compaction, rehabilitated soils may require remediation, such as tile drainage for tender fruit production (Lowe 1979).

Appropriate drainage control seems to be best achieved, and has the firmest basis in geomorphic and hydrological principles, when the hydrological basin is construed as “the natural unit” for artificial topographic relief construction (Nicolau 2003). The slopes and watercourses comprising individual basins, including safety structures to prevent destruction during heavy precipitation, determine how topographic relief is organized and constructed. Appropriate designs are used to manage the surface of the basin, patterns of drainage networks, slope and channel morphology, and structural elements for controlling runoff and sediments, such as regulatory ponds.

In some cases drainage designs can mimic features of the natural surrounding landscape, as demonstrated at the Shek O Quarry in Hong Kong (Figure 3) (Janet Forbes, pers. comm., August 7, 2009; Hogan et al. 2007), but more frequently artificial structures are required, such as ponds to trap sediment and high-volume runoff. The construction of short banks with ever-more-gentle slopes to concentrate runoff, in combination with well-defined watercourses deep enough to drain peak flows, successfully controlled drainage in one mining situation. Sawatski et al. (2000) recommend "passive" erosion protection measures in water channel construction, as opposed to more traditional active measures such as riprap, drop structures, and rigid lining. Passive measures include controlling basin size and structure to prevent large single-channel discharges, creating floodplains to attenuate flow velocity and peak flows, and laying waste rocks or boulders under drainage channels to introduce a self-healing capacity.

**Figure 3 - Watercourse Feature Under Construction January 2009: Shek O Quarry, Hong Kong (Credit: J. Forbes)**

Biotic as well as abiotic controls of water channel dynamics have been recognized as important to drainage of rehabilitated extraction sites. Experiments performed on artificial slopes at a reclaimed coal mine in Spain revealed that slopes covered with topsoil had improved drainage over slopes formed of overburden alone, and this difference was largely due to grassland vegetation cover on topsoil improving soil infiltration and reducing runoff (Nicolau 2002). This finding validates the long standing statutory requirement in most jurisdictions for rehabilitation to establish a vegetative cover as a minimum standard.

Hydrological processes within rehabilitated extraction sites may have impacts on groundwater resources through a variety of mechanisms. These include direct mixing of confined and unconfined aquifers through naturally porous or artificially drilled areas of submerged quarry basins (Jansen et al. 1999; Wollschlager et al. 2007), and downstream effects of runoff and sediment transferred from extraction sites.

One concern for groundwater safety arises when old pits and quarries are used as waste-disposal sites (Bumb et al. 1997; Norrman et al. 2005; Perozzi & Holliger 2008). Approaches to dealing with such threats generally involve careful engineering design, computationally-intense hydrological monitoring programs (Navarro & Carbonell 2008; Perozzi & Holliger 2008), and the creation of wastewater treatment and groundwater recharge plants where needed. Novel technologies include the development of groundwater extraction wells and recharge trenches at an active sand and gravel pit in Ohio that is simultaneously operated as a landfill (Bumb et al. 1997). In Italy, a novel approach to preventing mixing between an unconfined quarry aquifer and a confined groundwater aquifer was to create a submerged “slurry wall”, a non-structural vertical diaphragm of low-permeability (De Luca et al. 2007).

In Ontario, the operation of a particular gravel pit included the construction of a hydraulic buffer in order to create a “below-ground dam” that retains groundwater to supply the Warnock Lake in the Town of Caledon and, by extension, the function of the provincially significant Star Wetland Complex. This approach has allowed for the extraction of aggregates on adjacent lands, while maintaining the water table and allowing for the continued functioning of the wetland (Greg Sweetnam, pers. comm., July 30th 2009). The same principle of a hydraulic barrier exists at two other gravel pits in the Township of Puslinch to protect the adjacent Mill Creek, a coldwater fishery. More active recharge of adjacent lands is employed at a quarry in Milton Ontario, where surface water collected in the quarry is re-injected into the surrounding bedrock to recharge the ground water table and thus protect the adjacent cold water creek and wetland complex.

Importantly, the presence of quarry and gravel pit lakes are being recognized as potential positive forces in the landscape with respect to influencing drainage patterns and managing water resources in the wider hydrological region. For example, in Mediterranean Spain arid conditions punctuated by periods of intense precipitation can lead to serious erosion and flooding problems regionally; however, numerous gravel pits combined with check-dams scattered across the landscape minimize such problems by retaining runoff and promoting groundwater recharge (Martin-Rosales et al. 2007). A contrasting example is provided by a large quarry lake near Milan, Italy, a region faced with the problem of rising groundwater due to changes in land use. A pumping experiment at the quarry lake, in which water was actively removed from the lake and diverted to off-site agricultural uses demonstrated that significant groundwater drawdown could be achieved, providing a medium to long-term solution to the threat of flooding prevention in nearby urban subterranean structures such as subway tunnels (Beretta et al. 2004). Furthermore, a quarry in Chicago, US, was deliberately extracted with the purpose of providing a water storage reservoir for the needs of the city, and now functions as an important reservoir.

## 2.5 Developing Healthy Soils

Global research on technologies and applications related to soil development at mineral extraction sites is very active on several fronts, including monitoring of soil properties and processes, assessing the ecotoxicological risks of different soil amendments, assessing effects on plant growth and community ecology of different soil amendment strategies, and assessing effects of different amendments on site conditions including soil nutrient status and structural properties. In particular, finding the most effective ways to utilize fines, spoils, or other waste products from both extractive and non-extractive industries comprise very active research areas.

Active management of soil development in the rehabilitation of mineral extraction sites generally takes one of two forms: 1) pre-planned identification and removal of soil materials including topsoil prior to extraction, proper storage during extraction, and replacement as soon as possible after rehabilitation; or 2) creation of new soils through recycling of extraction spoils or by-products and combining with chemical fertilizers and/or organic materials such as paper waste and sewage sludge. Often the strategy adopted depends upon the level of rehabilitation planning embraced prior to extraction. Additionally, given the nature of some aggregate operations and the need to backfill slopes at least to some extent, more soil materials are often required for rehabilitation than was removed prior to extraction (exceptions being when large portions of mined sites become aquatic habitat).

Early work on standard best practices for handling soils in pit and quarry rehabilitation was developed for forestry and agriculture in the UK with the objective of establishing a good soil profile and achieving maximum crop productivity. In the UK, the industry lobbied for changes in central government policy to allow mineral extraction in certain areas. Central to this issue was the quality of soils, with the UK categorizing soils into various grades depending on physical characteristics as directly influencing the workability and the range of farming. Grades 1, 2, and 3a are collectively referred to as the "Best and Most Versatile Soils (BMV)" and allow for the greatest choice in cropping. It was assumed that mineral extraction on land supporting BMV soils would translate to a standard that was below that of the former land use. With the BMV soil areas supporting many of the important sand & gravel deposits particularly in floodplains, the industry undertook extensive research into both the mechanics of soil handling (as part of "restoration") and on the remedial cropping following completion of restoration (referred to as "Aftercare Management"). The mechanics of soil handling involved:

1. Consideration of the condition of the soil and timing of movement. This is typically related to soil moisture content where most mineral permits will have a condition stating that soils are not normally moved during the period October through to March when they will normally be at field capacity (i.e., high moisture content). Movements within the period April - September are only permitted when the soils are in a "dry and friable condition", which is usually related to the "plastic limits" of the particular soil. There are also restrictions imposed following "rainfall events" to stop operations during rainfall and for a period following the event, the length of the period dependent on the intensity of the event; and,

2. The actual operation, machinery etc., employed in the movement of soils. The basic requirement is to avoid mechanic damage to the soil and to avoid soil compaction, particularly at depth. Research linked with fieldwork led to the development of "Good Practice Guides for the Handling of Soils" (DEFRA 2009).

As far as the 'aftercare management' is concerned, the research gave rise through legislation to the "standard aftercare period" of five years: the aftercare period is defined as the period of time required to bring restored land up to a standard that will support the intended after-use. The aftercare period was specifically designed for agricultural restoration but is extended to other land uses (nature conservation, forestry) where there is now a recognition that the 5-year period is too short and through other legal agreements, the aftercare period can be extended an additional 5 to 25 years. During such time that the operator is responsible for the management of the restored land. In the agricultural context, the main aim of the aftercare period is to restore "soil structure" through the use of appropriate cropping (normally vigorously rooting grasses and/or cereals).

Soils at Lafarge's Harrycroft Quarry were classified as Grades 3a and 2, with some 3b, prior to extraction such that the objective in restoration was focused on a return to at least the same agricultural standard. Inert waste was brought to the site and graded out in layers, with the final profile consisting of 'clean fill' (i.e. clay, limestone, quarry waste) with a cover of topsoil. This approach ensured that the final profile integrates almost imperceptibly into the local landscape. The topsoil was then cultivated using a combination of ploughing/discing/harrowing to produce the necessary seedbed tilth for the establishment of the grassland for hay production. The planning included a 5-year aftercare period, including soil sampling, fertilization/liming, and weed control (David Park, pers. comm., September 18th 2009).

Finningley Quarry is situated in an area known as the "Idle Lowlands Character Area" with soils that are inherently low in fertility but well suited to arable and horticultural cropping. The approach to restoration did not include the importation of materials to achieve the appropriate elevation; however, careful design of contours was used to ensure that the lower than original ground level was fully integrated into the surrounding landscape. The restoration included the application of an innovative approach including the inversion of the soil profile that has translated to an improvement in the agricultural quality of the land (i.e. from Grade 3b to 3a) by eliminating drainage problems associated with a massive clay subsoil. The latter was placed at the base of the restoration profile with overburden replaced over the subsoil to achieve the final restoration profile. A comprehensive piped drainage system was integrated into the restored lands, with water diverted into the underlying aquifer.

Lafarge – UK has also recently begun researching a new methodology – "the peninsula method" – aimed at avoiding the compaction at depth within the subsoil layer. This approach involves the use of low ground pressure dozers to push out the soils over top of sub-bases that have been previously engineered to the desired levels. This topsoil will act as a 'cushion to absorb pressure from the dumptruck wheels, thereby preventing compaction of the lower levels of subsoil. In this way, compaction of soils is restricted to the topsoil and upper levels ( David Park, pers. comm., September 18th 2009).

Efforts to employ extraction spoils and/or various fertilizers and organic amendments have met with considerably more mixed success, although there are some general trends of note. A foundational study at UK limestone quarries found that the addition of a relatively balanced low-dose chemical fertilizer (e.g. 2.1 g/m3 N:P:K:Mg at 2:2:1:1) led to a significant 7-fold increase in vegetation cover, an effect that was itself doubled if fertilizer was combined with seed addition and rabbit exclusion (Davis et al. 1985). Follow up studies confirmed the important role of balanced fertilizer in maximizing vegetation cover (Davis et al. 1993), however it was noted in both cases that maximum cover correlated with decreased rather than increased species diversity.

In a similar UK study limestone spoils became heavily covered by a single dominant grass species when seeds were added alongside NPK fertilizer, but became covered by diverse immigrant moss species when grasses were sown with a manure amendment (Dixon & Hambler 1984; Hambler & Dixon 1986). Heavy fertilizer use may therefore be incompatible with sites designed for high-diversity. Experiments conducted at a slate quarry in Wales cast a slightly different light on this issue, however. While balanced fertilizer addition did favour growth of dominant plant species but not immigrant moss species, high-cover plant communities led to more diverse ecosystems overall by increasing the abundance of plant-eating invertebrate species (Rowe et al. 2006). In Ontario, quarry floors seeded with herbaceous alvar species produced more diverse communities when a low-nutrient soil amendment (silica sand and peat moss) was added compared to when a high-nutrient amendment (silica sand, peat moss, and slow-release nitrogen fertilizer) (Richardson et al. 2009).

More recently, important insights into successful soil management strategies at extraction sites have been gained through comparative monitoring of soil profiles and processes at spontaneously revegetating sites, sites rehabilitated long ago, and recently abandoned or rehabilitated sites. Investigation of naturally occurring soils on ledges and in depressions of granite quarry cliff faces in China revealed that within 7 years of site abandonment soil composition was almost identical to that of adjacent gardens on flat ground, indicating that cliff-face soil accretes relatively rapidly via immigration from off-site, rather than developing on-site via weathering processes (Yuan et al. 2006). An implication of this finding is that soil development in this context may need minimal human assistance for effective rehabilitation.

While many studies deal with the influence of soil on vegetation (discussed below), investigations of soil dynamics over successional time (e.g. 5-25 years) at extraction sites either left to revegetate spontaneously, or actively planted with target species, indicate that vegetation can have important influence on soil development. Critical humus formation, nitrogen, and carbon concentrations increased considerably over time in “reclaimed” substrates (treated with various amendments and planted with tree seedlings) relative to spontaneously revegetating substrates, both in Czech clay dumps (Abakumov & Frouz 2009) and in Polish sand mines (Pietrzykowski & Krzaklewski 2007).

Long-abandoned limestone quarry floors in Ontario spontaneously developed soils that were nutrient poor and sandy in contrast to soils of the surrounding landscape but matching soils of distant alvar sites almost exactly (Tomlinson et al. 2008). Thus, the utility of natural versus amended substrates at a site depends upon the particular rehabilitation goals. Soil surveying at sand and gravel pits in New Hampshire illustrates the importance of improving capacity to understand and classify soils in such environments, which have traditionally been neglected by soil scientists (Strain & Evans 1994). Modern efforts to monitor soil properties and dynamics at rehabilitated gravel pits in Switzerland experimented with ground-penetrating radar and near-infra-red photography employed during aerial surveys (Friedli et al. 1998). Such technologies show some potential to detect soil properties such as stoniness and water content, as well as vegetation cover, but further improvements to the technologies are needed: traditional macro-morphological soil profiling cannot be abandoned quite yet. A recent advance in soil understanding has allowed researchers in China to develop indices for rapidly classifying soil status at recovering limestone quarries in order to improve the efficiency of rehabilitation monitoring (Zhang et al. 2007). Such indices take stock of well-characterized relationships between soil pH and organic matter content.

Soil management practices at Australian mineral sand mines, including separate removal and storage of the first 5 cm and the subsequent 10 cm cuts of soil materials, have proven very successful for the rehabilitation of shrubland, dune, and outcrop communities of exceptional species richness (Herath et al. 2008). Similarly, rehabilitation of limestone quarries in southern Africa to thicket ecosystems was improved by return of soil materials and thicket mulch, particularly upon the floors of deeply excavated sites where soil was absolutely required (Hall et al. 2003; Burke 2008). Careful identification, removal, storage, and replacement of the topsoil and underlying subsoil was likewise a critical component of successful progressive rehabilitation of a Niagara Escarpment quarry in Ontario (Zimmerman & Lowe 2001).

Interest in applying sewage sludge as a remedial amendment for substrates found on or added to extraction sites has been particularly strong in Spain, where considerable research has been conducted on the effect of sewage on soil nutrition and physical properties, as well as potentially toxic side effects such as heavy metal contamination. At six limestone quarries in northeastern Spain, plant communities spontaneously colonizing parts of the quarry floor where treated sewage sludge had been applied to residual soil (a mixture of quarry spoil and previous topsoil) were compared to plant communities colonizing untreated residual soil (Moreno-Penaranda et al. 2004). Sewage sludge communities were more productive and provided higher vegetation cover than untreated communities, however they were dominated by ruderal species, they supported fewer species overall, they supported fewer legume species, and species composition did not resemble that of untreated communities.

In a separate trial, sewage sludge mixed with residual soil located on a 28 degree slope was discovered to exhibit 90% less sediment erosion upon experimental rainfall than residual soil alone (Sort & Alcaniz 1996). This effect held in general whether vegetation was absent or present, and whether the sewage sludge was mixed with or added on to of the residual soil. Follow-up research determined that the effect was due to improved soil aggregate stability following sludge addition, however it was also reported that structural impacts of the treatment were greatly weakened in the year following sludge addition (Sort & Alcaniz 1999). Studies on the chemical properties of sewage-sludge treated quarry- or clay-soil indicate that while leachates from such soil contain significantly higher nitrates and ammonium than untreated soil, concentrations of heavy metals such as cadmium, nickel, zinc and iron were insignificant and well within safety regulations for agricultural uses. However, copper content was above the agricultural safety limit (Lozano Cerezo et al. 1999; Almendro-Candel et al. 2007).

Investigations into chemical and physical properties of extraction spoils indicate some potential for such materials to be utilized in soil development at rehabilitation sites, provided that they are combined with appropriate organic components. For example, slate processing fines have potential to improve water retention at rehabilitated slate quarries in Wales due to their aggregate size, while the pH and electrical conductivity of such fines are within the tolerance limits of most plants (Paradelo et al. 2008). Field-testing of this idea revealed that trees planted in pockets on slate quarry waste exhibited increased growth when pockets received slate processing fines and compost compared to compost alone (Rowe et al. 2005). The potential for water-absorbing polymer gels to perform a similar function were tested in this same trial, but found to have little benefit to plant growth, echoing results from a similar trial at a limestone quarry in Portugal (Clemente et al. 2004).

Alternatives to fertilizers, sewage sludge, and topsoil as the organic component of rehabilitation soils, such as wood ash and de-watered, uncomposted pulp sludge from paper-making processes, have been investigated and in the United States and found to hold some promise, exhibiting low toxicities and providing moderate nutrition for plants as well as improvements to soil structure (Catricala et al. 1996; Carpenter & Fernandez 2000; Jones et al. 2009).

## 2.6 Introducing Plant Species and Communities

Investigations into strategies and technologies related to the introduction and establishment of vegetation at extraction sites generally seek to understand applications for natural heritage after uses: 1) which community types, functional groups, species, or cultivars can effectively be established or colonize high-stress environments under no active rehabilitation; 2) how to best collect and introduce plant material required for propagation; and/or 3) what types of additional environmental modifications or amendments are useful for achieving successful revegetation over the long term. In most trials cost-effectiveness to managers is attributed high importance, but recently emphasis has moved away from simply establishing "green" cover to meeting stated biodiversity and ecosystem function goals. Increasingly the importance of species interactions in determining the trajectory and overall success of revegetation is being recognized, but on this front more research is needed before useful applications become a reality.

Depending on the success of active rehabilitation techniques sites such as exhausted quarries or gravel pits present challenges to revegetation efforts by virtue of the high stress imposed on most colonists, ranging from substrates with poor nutrient status, moisture retention, or structural stability (for example, due to steep slopes), to high thermal stress, to periodic flooding events. Given the scale and extreme physical conditions of many extraction operations, intensive efforts to develop soils, create microclimates, and nurture plant growth can be a costly process. Thus the focus of much research has been on identifying plant taxa that can effectively colonize extraction sites following planting with only minimal requirements for largescale amendments to the biophysical conditions.

Early work at UK limestone quarries set the bar for practical rehabilitation as the achievement of rapidly-establishing visually acceptable vegetation cover, without much concern for the diversity or indigenous origin of the plants. In one series of studies only a single common grass species (*Festuca rubra*) was seeded to quarry spoil plots under various environmental treatments (Dixon

& Hambler 1984; Hambler & Dixon 1986; Dixon & Hambler 1988), while in another study seeds from one grass and one very common legume (*Lotus corniculatus*) were added (Davis et al. 1985). Other early work on UK quarries complemented trials of common grass and legume species (aimed at “quick and easy” revegetation) with trials of multi-species communities aimed at recreating a local ecosystem of high conservation priority: magnesian limestone grasslands (Richardson & Evans 1986).

Overall these experiments determined that relatively high vegetation cover could be established quickly on resident quarry spoils provided that some minimal efforts were employed to improve substrate nutrient status. However, attempts to recreate native grassland communities were less successful than work with commercially available cultivars of well-known drought-tolerant species, and use of low-diversity, non-native seed mixes of grasses and legumes predominated rehabilitation practice for many years.

Along with the advent of efforts to replicate natural landforms surrounding daleside UK quarries, diverse native grassland species again became represented in the seed mix added – though this time via hydroseeding technology (Wheater & Cullen 1997; Cullen et al. 1998). While downsides of the “restoration blasting” technique for geotechnical stability have been mentioned, from the perspective of revegetation the technique was highly successful, as diverse grass, legume, and other herb species became well-established despite steep slopes and harsh conditions, and seeded sites significantly resembled natural dalesides more than spontaneously revegetating sites (Cullen et al. 1998). Interest in creating magnesian limestone grasslands on appropriate UK quarries appears to be rising again, given recent investigations into the best method of seed collection for such endeavours (Riley et al. 2004). Harvesting using small hand-held vacuums (optimum time: mid-August to early September) holds some promise, particularly for species that cannot be purchased commercially. Vacuum-harvesting was found to be at once more efficient than hand collecting and more conducive to harvesting at typical quarry and conservation areas than tractor-harvesting.

Similar efforts to experimentally establish grasses, legumes, and other herbs via seed addition – with minimal substrate reclamation – have been undertaken in semi-arid Mediterranean Greece, interestingly with many of the same species used in the UK trials, available commercially and valued for their resistance to drought (e.g. *Trifolium repens*, *Lolium perenne*). Ten centimetres of previously removed topsoil applied on top of spoils at a limestone quarry site and hand-seeded with six species from commercial as well as native sources revealed that several of the species could establish with high-cover rapidly and resist drought conditions (Abraham et al. 2009). Grass and legume species required no soil preparation whatsoever at a Turkish quarry in order to establish with high cover (Arambatzis & Kitikidou 2008).

At limestone quarries in Ontario, introduction of stress-tolerant but often non-native and low-diversity seed mixes is commonly practiced, alongside fertilization, mulching, topsoil addition, and other moderate-intensity soil reclamation regimes, with the intent of providing vegetation with erosion control, especially on back filled quarry slopes. Variations of this practice were evident at most Task 1 sites. However, recent evidence suggests that high-diversity native grass and herb communities can establish on old quarry floors with virtually no reclamation efforts other than seed addition, provided that appropriate species are used (i.e introduced species have already adapted to quarry-like conditions by virtue of evolutionary life-histories on natural alvar limestone pavements) (Richardson et al. 2009). Similarly, moderate substrate amendments led to the successful establishment of several seeded native tundra species at gravel pits in northern Manitoba (Rausch & Kershaw 2007).

Experimental rehabilitation of aggregate extraction sites to shrublands or woodlands is only slightly less common in the literature than introduction of herbaceous vegetation. In Africa topsoil removed from a mesic succulent thicket ecosystem prior to limestone quarrying was replaced after extraction in the hopes of recovering the highly valued thicket vegetation; however, even after 16 years the resultant ecosystem bore low resemblance to thicket, though colonization by many successional shrub and tree species was well underway (Hall et al. 2003; Weatherall-Thomas & Campbell 2006). In Australia more success was had by reintroducing topsoil as well as seed-bearing mulch made from cuttings (at 30 cm) of high-diversity shrublands in the vicinity of mineral sand quarries (Herath et al. 2008). Research into the use of cut grass with associated seed to encourage vegetation growth by spreading it over the floor of closed-down quarry in Germany found that 50 to 60 % of the species established on the areas and naturalized in one single mowing process (Brodkom. 2000)

Elsewhere in Australia seed broadcasting enabled successful revegetation of sand quarries to native Banksia woodlands (Rokich et al. 2002). Under sloped clay gravel-pit conditions in Italy, 24 native tree and shrub species were planted as saplings without remediation of the high-pH, low-organic matter soil, and several were discovered to survive excellently, earmarking these well-adapted species for use in future rehabilitation work (Muzzi & Fabbri 2007). Similarly, several native sclerophyllous shrub species were found to survive drought conditions well in Portugal when 2-year old nursery plants were planted alongside sandy soil, placed in 50 cm-deep holes that had been dug in the 1m layer of limestone marl that had been poured on quarry terraces (Clemente et al. 2004). A plantation of hybrid aspen trees was established with moderate success on a calcareous reclaimed oil shale quarry in Estonia (Tullus et al. 2008), and tree species established well when compost-filled bags containing saplings were placed within “pockets” that had been dug in a Welsh slate quarry and filled with slate processing fines (Rowe et al. 2005).

Aside from hydroseeding of “restoration-blasted” quarry slopes in the UK, less attention has been paid to revegetating steep slopes and cliff faces at extraction sites than more level terraces, berms, or quarry floors. However, some insight for revegetating mineral quarry slopes in the Mediterranean may be taken from experimental hydro-seeding of steep motorway slopes in the same bedrock region as numerous quarries. For example, hydroseeding with vegetal mulch and humic acids reduces erosion (Montoro et al. 2000), and use of a nurse-crop can slow natural succession of adapted native species (Zelnik et al. 2008).

The novel approach recently employed at granite quarries in China of pneumatically drilling 30 cm-deep holes directly into steep rocky slopes and planting seedlings of known cliff-climbing species present high potential for more rapid and complete revegetation of such extreme environments (Wang et al. 2009).

A large proportion of the experimental plantings described above employed some form of mulching or other mechanical method of providing shade, retaining moisture, or reducing erosion. In general, mulching almost always has some positive effect, although it can also be associated with negative effects such as attracting rodents and depleting certain nutrients. Nonetheless, often research has been directed at determining which particular type of mulch, or combination of mulch and other amendments, is most effective. For example, hydroseeded limestone spoils in Greece established greatest vegetation cover when straw mulch was applied, but little additional benefit was gained from fixing planting in place with plastic netting of water-soluble asphalt (Brofas & Varelides 2000). Elsewhere in Greece powdered bentonite mulch had strong positive effects on herbaceous plant survival, while initial strong effects of bentonite combined with straw or asphalt on establishment did not translate to benefit for long-term survival (Abraham et al. 2009). On sloped clay soils in Italy straw mulch combined with tar checked erosion and promoted high grass cover, as did use of jute on tilled soil (Muzzi et al. 1997). Softwood bark waste employed in rehabilitation of UK quarries to magnesian limestone grassland had marked positive effects on plant growth, though this was more in the context of improving substrate structure by opening upper layers to air and water, rather than traditional mulching (Richardson & Evans 1986). In this regard peat moss and topsoil were also effective amendments.

One objective of revegetation research seeks to understand the effects of species to species interactions on rehabilitation success. While some interactions are negative (eg herbivory by species such as rabbits) (Davis et al. 1985), positive interactions among species may be particularly important for the rehabilitation of high-stress environments (Padilla & Pugnaire 2006). Such interactions may take the form of facilitation by hardy nurse plants that provide shade and moisture-retention during establishment of more sensitive species (Zelnik et al. 2008), or symbiotic plant-microbe interactions. In Mediterranean Lebanon quarry rehabilitation through planting of legume species showed high promise when symbiotic relationships between legumes and nitrogen-fixing rhizobium bacteria were first identified in the field then actively cultured in the nursery prior to out-planting (Brune et al. 2007; Atallah et al. 2008). Downstream effects of effective symbiotic relationships provides benefit not just for legumes but for other introduced or spontaneously colonizing species due to improved soil nitrogen content. Legume species introduced to a limestone quarry in the outer range of the Himalaya mountains established, grew, and survived better when seeds where encapsulated in polyacrylamide alongside rhizobia bacteria, compared to when no rhizobia was added (Jha et al. 1995).

Another important symbiont, mycorrhizal fungi, can interact positively with the roots of many plant species by providing phosphorus, potassium, and other nutrients in exchange for carbon. Mycorrhizae can additionally improve soil structure through growth of radial networks of fungal hyphae that both increase air space and produce sticky residues that contribute to soil aggregation. Efforts to employ mycorrhizal fungi in rehabilitation of extraction sites are only now developing (Harris 2009), and data from the Task 1 sites further support the need for additional research in this realm. While inoculation with arbuscular mycorrhizal fungi yielded no benefit to shrubs planted on Portugese quarry terraces (Clemente et al. 2004), a UK quarry undergoing rehabilitation to heathland showed greater plant growth of heather where stronger plant-mycorrhizae symbioses were found (Diaz et al. 2006).

Aside from plant-microbe interactions, plant-plant interactions associated with increased biodiversity may importantly influence the success of revegetation. Introduction of plant species which are considerably different from one another with respect to resource requirements and impacts on the environment may compete less and facilitate each other more than plant species that are functionally very similar. Thus total resources in an environment might be converted to plant growth and survival more efficiently when a greater diversity of species is established. Such trends have been observed in rehabilitation of moderately-stressed ex-arable agricultural sites (Bullock et al. 2007), but few studies have investigated biodiversity effects in extreme-stress sites. However, recent evidence from Ontario limestone quarry floors seeded and/or planted with characteristic alvar species at different levels of species diversity indicates that species number above, and beyond species identity, has a strong positive influence on plant growth and survival (Richardson 2009).

## 2.7 Habitat Enhancement

The available literature on post-extraction site rehabilitation provides little evidence of specific efforts to enhance the value of sites as habitat for diverse species. In fact, far more information about the potential for sites to provide effective refuge to flora and fauna of high conservation value can be found in the literature on passive rehabilitation (Section 1.1). Of course stabilizing substrates, improving their structural properties for plant growth, and increasing their nutrient content comprises considerable improvement of sites as "habitat" for plants, and the presence of particular plants can improve habitat quality on site for other organisms (for example, rabbits at UK limestone quarries; (Hambler & Dixon 1986)). But aside from such basic steps common to most revegetation projects, there are only a few examples of intentional design of sites to improve habitat quality. Interestingly, most of these are in aquatic areas of extraction sites. Examples of specific site manipulations with unintentional positive consequences for biodiversity also deserve note.

Rehabilitated gravel pit lakes in England were altered to improve their capacity to provide refuge for Tufted duck (*Aythya fuligula*) populations by removal of fish, which were competing with the ducks for invertebrate prey species (Giles 1994). Use of the site for nesting and survival of adult Tufted ducks increased as a result of the fish removal. Additionally, growth of macrophytes was stimulated, which improved the habitat value of the site for wintering waterfowl communities. Similarly, fish removal at two other gravel pit lakes in the UK was found to enhance habitat conditions for submerged macrophyte species considered important to the development of the rehabilitated sites (Wright & Phillips 1992). Construction of wetlands within gravel pits in Illinois led to sites providing nesting habitat to two state-endangered species (Least Bittern, Yellow-headed Blackbird), and foraging habitat for three state-endangered species (Pied-Billed Grebe, Great Egret, Black-crowned Night-Heron) that visited sites during the breeding season. Unfortunately particular features of the constructed wetlands leading to its increased habitat value for waterfowl were not elucidated (Hickman 1994).

A gravel pit lake in Minnesota became polluted with high-phosphorus wastes after seven years of after-use in salmonid aquaculture production. Government-mandated restoration of lake water quality to pre-aquaculture conditions was accomplished through artificial aeration for one summer, effectively burying solid phosphate wastes under a layer of natural sedimentation from the basin walls. Reinitiated phosphorus-limitation reduced algae growth in following years, improving conditions for slow natural succession towards a species-rich lake ecosystem (Axler et al. 1998).

A novel approach to improve the habitat quality of alluvial sand and gravel pits for riparian plant communities was attempted in Colorado through active drainage control. Water levels in pit ponds were annually drawn down for several years during the time of seedfall of characteristic native riparian species, providing bare, moist substrate conducive to establishment (Roelle & Gladwin 1999). Furthermore, establishment of a non-native problem species was controlled for by re-flooding in late fall. Due to high variability in plant establishment over the experiment the effect of the draw-downs on plant establishment was unclear (through establishment was generally high), however control of the invasive species via flooding was apparently strong. Water levels were controlled via a drain culvert equipped with a screw gate.

In the Czech Republic managed flooding was similarly used to promote fish diversity in gravel pits located in a river floodplain (Jurajda et al. 2004). Pits that were actively flooded in the spring experienced improved fish spawning and nursery habitat relative to pits that were not flooded, and by autumn fish species richness and overall abundance was significantly greater in the ponds that had been flooded initially.

Rehabilitated gravel pit lakes in the Netherlands were found to provide excellent habitat and breeding grounds for diverse dragonflies as a result of earthmoving to create “natural” looking shore banks and floodplains (Calle et al. 2007). Such rehabilitated gravel pit lakes supported more species of dragonfly than natural lakes in the region, although this may be associated with fewer or no predatory fish. Perhaps related, bank- angling of constructed gravel and clay pits in the UK appears to be an important factor contributing to the value of such habitats as refuge for diverse plant species (Linton & Goulder 2000). Earlier investigations of Dutch gravel pit lakes as refuges suggests that the presence of areas where water can stagnate over summer months is responsible for the high-value dragonfly habitat (Wildermuth & Krebs 1983).

The size and structure of extraction sites and features therein may have important implications with respect to habitat provision. A study of Czech gravel pits suggests that the importance of ponds within pits as amphibian habitat increases with the number of distinct ponds created in a pit; active construction of multiple ponds in rehabilitated pits may thus increase amphibian diversity (Skoda & Pivnicka 1986). Similarly, the importance of quarries, active or abandoned, as wild bee habitat increases with the area occupied by the quarry, suggesting larger quarries may actually be better for biodiversity in some contexts (Krauss et al. 2009). In contrast to the bee study, the value of Dutch gravel pits as habitat for rare and endangered ant species decreases over time as sites undergo succession to shrub and woodland, and thus maintaining “young” disused gravel pits could have particular conservation value for such early-successional species (Wouter et al. 2009).

## 2.8 After-care of Rehabilitated Extraction Sites

In theory long-term monitoring and adaptive management or after-care practices are among the most crucial steps in ecosystem rehabilitation (SERI 2004), but unfortunately in practice such steps are often the first abandoned under typical budget constraints on academic and industrial research programs. Such seems to be the case for the rehabilitation of mineral extraction sites judging from the literature gathered; if research on the effects of various after-care practices exists, for the most part it does not appear to be published in the peer –reviewed science and engineering literature. Chief exceptions include monitoring of vegetation composition at extraction sites actively rehabilitated 10-30 years prior, and comparison of such sites to unexploited sites and sites undergoing spontaneous recolonization over similar time-frames. Already-mentioned examples include Australian sand quarries and shrub lands (Herath et al. 2008), and African limestone quarries targeted towards thicket recovery (Hall et al. 2003). However, these are merely assessments and do not test actual after-care practices, such as removal of undesired species.

The primary goal of long-term maintenance and after-care programs at rehabilitated sites is to ensure to the extent possible that rehabilitation goals are being met. From an ecological viewpoint the chief goal of rehabilitation is establishment of ecosystems – whether for natural heritage purposes, agriculture, recreation, or other uses – that are stable. Not necessarily unchanging – stasis is hardly natural – but also not reverting back to an undesired degraded state, such as a barren environment supporting little biodiversity and few ecosystem functions (Suding & Hobbs 2009).

While long-term monitoring may be necessary to assess stability and adaptively manage problems when they arise (Holling 1973), recent research suggests that controls of ecological stability may be manipulated at the outset of rehabilitation work, improving the likelihood of long-term success. In particular, the diversity of species introduced or established in a rehabilitated ecosystem may have a positive impact on the capacity of the ecosystem to resist and recover from environmental disturbances. In an Ontario quarry, long term monitoring of vegetation and wildlife established much useful information on the successional development, including the recruitment of native species, the occurrence of regionally rare species and the development of plant communities in 10 to 15 years (Zimmerman & Lowe, 2001). Understanding how to apply biodiversity in order to achieve long-term stability in rehabilitated ecosystems is only now developing (Seabloom 2007), but exciting results from experiments on Ontario limestone quarry floors suggests that communities where more alvar species are established are able to resist intense drought and heat waves better than communities with only few alvar species (Richardson 2009).

Similarly, some early experiments on UK limestone quarries are valuable in that they were monitored for ten years or more (Richardson & Evans 1986; Hambler et al. 1995). Interestingly, while a five-year UK study predicted that rabbit populations on quarry floors may need managing as a form of after-care for the establishing plant communities experiencing grazing stress, a 10-year study concluded that the presence of rabbits at rehabilitated quarry sites benefited biodiversity overall, and might even be useful in making succession at such sites more predictable (Hambler et al. 1995). Rabbit grazing may prevent competitive dominance by palatable species, while environmental heterogeneity created by rabbit middens provides new microsites for plant colonization. Furthermore, over time the rabbits increased the nutrient content of the soil and stimulated progression to later successional stages.

Removal of non-target plant species or “weeds” is employed as a primary restoration measure in some ecosystems, and as a long-term aftercare in others (Seabloom et al. 2003). However, little information on weed removal in post-extraction sites exists. At Ontario quarry sites neither the addition nor removal of weed species had a biologically significant effect on the establishment of seeded alvar species, but the timescale of the treatments applied was very short (Richardson et al. 2009). Health concerns over spread of ragweed at Swiss gravel pits and other sites where herbicide spraying was deemed inappropriate spurred an experimental study that concluded the life cycle of this nuisance species could be partially broken by mowing twice per summer before seed ripens (Bohren et al. 2008). However, there is little evidence to suggest this would be a reasonable long-term management practice for rehabilitated sites in general. As mentioned in the context of habitat enhancement, managed flooding may be an effective long-term management strategy in some contexts, either to remove undesired species (Roelle & Gladwin 1999; Tallent-Halsell & Walker 2002), or foster recruitment of desired species (Jurajda et al. 2004).

One clear case of at least intermittent weed-removal as a necessary after-care strategy for extraction sites comes from Australia, where a series of gravel pit lakes were rehabilitated to provide a range of recreational uses, including boating and swimming (See Chapter 8 – Penrith Lakes). In this context submerged macrophyte vegetation was considered a problem, and an experiment was conducted to determine whether covering the macrophytes with plastic coverings would eliminate the problem (Carter et al. 1994). Use of black or black-woven coverings decreased macrophyte density by 90% after only 6 weeks, suggesting this application would be an effective solution where submerged vegetation is undesired. At similar recreational gravel pit lakes in Germany, lake eutrophication threatened continued recreational usage (Jobgen et al. 2004). Experiments revealed that eutrophication could be reversed via phosphorus removal using novel devices consisting of floatable / submergible plastic frames designed to support fleece made of polypropylene (PP). The PP fibers served as heterogeneous microhabitat for colonization by periphyton such as benthic diatoms and filamentous green algae, and the periphyton served as a means of removing phosphorous from the water and storing it as easily-removable biomass. Such biologically-based control systems of water quality may represent a practical technology for water management at other aquatic extraction sites at risk of eutrophication.

## 3.0 CONCLUSIONS

Here we have provided a global scan of strategies, technologies, and applications employed in the rehabilitation of mineral extraction sites, as evidenced by the peer-reviewed environmental science and engineering research literature. While not exhaustive – only 174 of the 514 references in the full "global scan" bibliography are cited herein – our review is comprehensive. We found the literature to be unevenly dispersed among research projects aimed at:

1. Identifying patterns of spontaneous succession and refuge provided by post-extraction sites where no active rehabilitation had been undertaken;

2. Planning active rehabilitation projects, including choosing overall goals, specific ecological targets, and geological design features capable of providing geotechnical stability;

3. Implementing such design features through earthmoving and blasting procedures at large scales, as well as rock-drilling, hammering, and surface-formatting at smaller scales;

4. Achieving effective drainage or hydrology at both terrestrial and aquatic post-extraction sites, while protecting groundwater resources;

5. Developing healthy soils at rehabilitation sites that are on one hand capable of supporting a variety of plants and other organisms, but on the other hand require minimal cost and safely recycle extraction spoils and other wastes wherever possible;

6. Introducing and establishing plant species, in some cases to achieve rapid low-cost “visually acceptable” vegetative cover, but in other cases to create specific community types with particular conservation or functional values;

7. Altering site conditions such that more valuable or effective habitat is provided to flora and fauna, either intentionally or unintentionally; and

8. Providing appropriate monitoring and after-care at sites to ensure rehabilitation success over the long term.

A relatively large proportion of the gathered ecology and naturalist literature applied to succession and refuge. In contrast, rehabilitation planning, land-shaping, and hydrology work was generally split between general concepts as well as field examples in the ecological literature, versus specific designs, theories, and case studies in the environmental geology and engineering literature. Soil development studies primarily came from ecological and eco-toxicological perspectives. Interestingly, whereas virtually all planting studies involved applied terrestrial plant ecology, much of the habitat-enhancement research involved aquatic ecology and management, including waterfowl, fish, macrophytes, and insects. We found few direct examples of research on after-care strategies, although a number of examples from the applied ecology, engineering, and management literature pertain indirectly. Within the different areas of study numerous geographical regions, extraction operations, and ecosystem types were represented, most notably limestone quarries, grasslands, and dalesides in the UK; Mediterranean limestone quarries, gypsum quarries, shrublands and xeric grasslands; Chinese granite quarries and outcrop climbing species; Australian sand quarries and shrublands; Italian clay pits and woodlands; Czech Republic limestone gravel pits, quarries, and successional grasslands; Ontario limestone quarries and alvar pavements.

The main conclusions that can be drawn from our analysis of the gathered literature are as follows.

1. There are a number of management goals that could be realized at any given extraction site; some of these are purely ecological, but equally important are geological, social and industrial goals. Furthermore, different goals can be at odds with one another: for

example, sites that are geotechnically stable and satisfy public safety goals may not easily support biologically-diverse or high-functioning ecosystems. Alternatively, allowing spontaneous succession to proceed uninterrupted may eventually result in ecosystems with high biodiversity, natural authenticity, or other conservation value, but either the timeframe for this process is too long for practical management purposes, or public safety may be compromised by site features such as open cliff faces or unstable slopes. Thus, broad and careful discussion of all possible rehabilitation goals should be engaged in by interested and impacted parties as early as possible.

2. Effective rehabilitation of extraction sites is possible, and once specific goals have been set, useful guidance on specific technologies and applications that can achieve these goals is abundant in the literature. Techniques ranging from specific designs for topographical relief and drainage systems (e.g. convex-straight-concave shaped slopes, catchment ponds) to particular planting methods (e.g. hand-seeding vs. hydroseeding vs. "pocket-planting"), have already been developed and tested to meet a wide variety of goals.

3. Some specific planting techniques are "tried and true", repeated many times in many systems and generally yield acceptable results. For example, hydroseeding drought-resistant grass and legume species alongside fertilizer and mulch consistently produces moderate to high plant cover on high-stress substrates such as limestone spoils. Addition of organic amendments to such substrates is usually helpful for plant growth and for reducing erosion. There is potential for safe use of recycled wastes such as sewage sludge in some cases, although such materials are not always ideal for target species. The biggest risk of fertilizer and organic soil amendments is that nutrient content will be excessive for many desired species, will foster the growth of a few dominant species at the expense of more uncommon desired species, and will produce a short term "boom" in plant growth followed by a "bust" of plant death when the nutrient pool is eventually exhausted. Application of symbiotic plant-microbe relationships in rehabilitation shows some promise, but on the whole more trials are needed. To date, work with nitrogen-fixing rhizobium bacteria has been slightly more successful than that with phosphorous-supplying myrcorrhizal fungi.

4. While cost-effectiveness will always be important, rehabilitation approaches are moving beyond simply obtaining the quickest, hardiest layer of vegetation cover – for example, through introduction of fertilizers, mulches, and commercial non-native, stress-tolerant cultivars of annual grasses – to developing high-value ecosystems with respect to biodiversity conserved and ecological goods and services provided. While the former approach can generally be achieved reliably and at relatively low cost, developing optimal methods for employing the latter approach will require further research.

5. Creation of ecosystems that effectively meet management goals - whether related to conservation or recreation, agriculture or industry – may be best approached in the future by combining the power of spontaneous succession with strategic human assistance. Introducing species that are already adapted to a given extraction site in its present, degraded state exemplifies this approach, as such species are likely to colonize the site naturally anyway, given sufficient time for immigration to occur. Alternatively, specific landscape engineering measures may be taken to first configure the "skeleton" of the site to resemble particular landforms of the target ecosystem (such as "restoration blasting"), followed by spontaneous and strategic assisted colonization by target species.

6. Rehabilitation goals such as preserving native biodiversity, establishing ecosystem processes, and achieving stable ecosystems, may complement one another. Realization of these goals may be achieved by applying ecological understanding of relationships between biodiversity and ecosystems. Species interactions including facilitation by nurse plants, symbiosis with microbes, predator-prey dynamics, and dampened competition with more dissimilar organisms may all play into the application of biodiversity itself to achieve functional, stable rehabilitated ecosystems, though further research is needed.

7. There is a dearth of direct empirical evidence supporting the existence or utility of particular active strategies for both enhancing the habitat value of rehabilitated extraction sites, and fostering long-term rehabilitation success through monitoring and after-care. The few examples however suggest that in some cases management practices such as weed-removal or grazing control are unnecessary, and potentially even detrimental. However, in cases where nuisance species are interfering with rehabilitation successes, novel approaches such as managed flooding may be employed. Further research needs to

establish specific methods by which an exhausted extraction site can be converted to and maintained as a “biodiversity hotspot”. Evidence to date suggests the potential for such conversion is high, and the likelihood that intensive aftercare will be needed is low, however further theoretical and empirical studies under a range of environmental contexts are required.

Heeding these suggestions in combination with closing the research gaps highlighted will enable rehabilitation of extraction sites in Ontario, and around the globe, to proceed with high efficacy in meeting social, industrial, and ecological goals.

# CHAPTER 10

# SAROS PAPER 6 REHABILITATION

# ALTERNATIVE AFTER USES OF PITS AND QUARRIES

# A GLOBAL SCAN

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## 1.0 INTRODUCTION

Task 9 sought to "*undertake a global scan of alternative uses of aggregate pits and quarries*", and the section explores the wide range of opportunities for rehabilitation after uses by examining case studies from around the world. Consideration is given to how rehabilitated sites meet a broad spectrum of human needs, including natural heritage landscapes, agricultural, recreational, and development demands that must be met. It includes a review of case studies gathered from a variety of sources, including websites of aggregate-producing corporations/associations and personal communications with select representatives.

Attempts were made to maximize the quality of case studies examined by seeking examples of rehabilitation projects recognized as successful by the aggregate production industry itself, as indicated by awards received from various industry associations. The global scan of extraction site after-uses presented here provides encouraging evidence that diverse social goals may be successfully met through knowledge-based and also creative rehabilitation that strives to comprehensively embrace both multiple conservation priorities and diverse human needs. Such varied goals can often be met within a single site due to overlap between features that foster conservation and those attractive or valuable to people. Furthermore, positive effects of successful rehabilitation may even extend far beyond the geographical boundaries of any particular site and can influence environmental and social dynamics at regional scales.

## 2.0 CREATION OF NATURAL HERITAGE LANDSCAPES – CONSERVATION INTERESTS

Rehabilitation of extraction sites to natural heritage landscapes – composed of ecosystem types that either existed on-site prior to extraction, or exist at present in surrounding areas –represents an important means by which aggregate producers can maximize the sustainability of their operations. Creation or restoration of natural heritage landscapes within aggregate extraction sites may not always be an optimal or feasible after-use once other planning and land use or social interests are considered, but in many cases it enables aggregate producers to mitigate changes to local ecological processes incurred during extraction. Efforts to create natural heritage features and functions within rehabilitated extraction sites can result in ecosystems providing similar ecological goods and services as their "natural" counterparts, while also offering a significant opportunity for public access and recreation.  The following presents a series of case studies of rehabilitation of pits and quarries to a variety of end land uses, but all with a focus on (re)creating natural heritage features and functions.

## 2.1 Integration with Surrounding Landscape

This “re-naturalization” approach apparently met with high success when employed at Heidelberg Cement’s “Shek O” quarry, located on Hong Kong Island, China. A well-designed and comprehensive rehabilitation plan was put into action at the 45 ha granite quarry, aimed at blending both the geographical and the biological features of the site into the surrounding rocky, steep-sloped Cape d’Aquilar Peninsula ecosystem, which is considered to have high conservation value. While this project is still underway, initial results are positive. The quarry blends in with its surroundings closely, emphasizing the high value of clear planning and a multifaceted approach to rehabilitation. Furthermore, beyond enhancing biodiversity on-site and re establishing regionally important landscape features, the site design at the Shek O quarry has provisions for additional human amenities, including a sculpted marine cove and roads and trails for public access and recreational activities. (Janet Forbes, per. comm., August 7, 2009)

**Figure 1 - “Shek O” Quarry, Hong Kong Island, China, 2001 (Credit: J. Forbes)**

**Figure 2 - "Shek O" Quarry, Hong Kong Island, China, 2004 (Credit: J. Forbes)**


**Figure 3 - "Shek O" Quarry, Hong Kong Island, China, 2005 (Credit: J. Forbes)**

Long-term planning, cooperation with local environmental experts, and care to integrate rehabilitation with natural processes has been vital to the success of rehabilitation at Holcim Ltd.'s "Cape Foulwind" quarry in Westport, New Zealand (Holcim Ltd. 2009d). This limestone quarry has been in operation for 50 years, and for the past 20 years progressive rehabilitation has been underway, steadily driving the on-site ecosystem to the end-goal of complete tropical forest and wetland recovery by the year 2040. The goal of this project is ecologically explicit – to restore a mosaic of native forest and wetland communities that would have existed prior to human contact, including high-quality habitat for the endangered fur seal and little blue penguin species. Revegetation methods have centered on out-planting native species that are being continuously produced (at a rate of 50,000 plants per year!) within a large nursery built on the quarry site. Out-planted trees benefit from the greenhouse's capacity to mimic quarry microclimate conditions and promote acclimatization prior to planting. However, considerable management efforts such as intensive water and soil monitoring have been required to maintain tree survivals, indicating lack of self-sufficiency and highlighting a potential drawback of the approach used. Nevertheless, for efforts applied and successes realized to date site operators were granted the MIMICO Environmental Excellence Award in 2007.

Another example of restoration focused on integration with the surrounding natural landscape is exemplified through Lafarge's Dinmor Parc Quarry located on the northern coastline of Anglesey in Wales, a designated Area of Outstanding Natural Beauty. In recognition of this designation, Lafarge sought to approach the restoration that would retain, to the extent possible, remnant semi-natural vegetation (e.g. calcareous grassland and maritime and cliff top grassland) in addition to extending these vegetation types over the extracted areas. The generally nutrient poor substrate associated with the existing bare quarry floors allowed for succession to communities that contain many of the characteristic plant species of the semi-natural vegetation types ( David Park, per. comm. September 18th 2009).

In other cases more natural or diverse mixes of tree species may be reforested to depleted extraction sites, such as when an original cover of forest was timbered and sold prior to extraction. Some aggregate operators choose (or are mandated by legislation) to return historical forest cover following extraction. Strategic management of reforested areas can yield economic benefits while minimizing detriment to the ecosystem. For outstanding rehabilitation in this latter category, Boxley Materials received a Bronze Environmental Excellence Award from the U.S. National Stone, Sand, and Gravel Association (Madison 2009). Lauded work included the planting of more than 50,000 trees at its Mill Point quarry in West Virginia.

## 2.2 Wetland and Aquatic Habitat Features

In the Czech Republic successful after-use of a gravel pit involved working with wetland communities that spontaneously colonized shallow flooded areas of the pit following landshaping (UEPG 2009a). The chief rehabilitation steps taken at the four pit lakes near Tovacov was to sculpt the landform of the lake edges to create littoral zones with particular characteristics essential for high quality fish and wildlife habitat, such as floodplains, and gradual rather than steep shorelines. Dredging of gravel was able to continue from lake centers without negatively impacting the created shoreline. The shaped littoral zones quickly became colonized by species of conservation interest, including such as beavers and terns. Islands were created in some of the lakes to provide further refuge for wildlife.

Deep lakes resulting from below water extraction can present some specific challenges in terms of rehabilitation. Water depths tend to restrict wetland habitat creation to these littoral shelves, which are typically narrow in response to the optimization of extraction (i.e., removal of rock to depth, to quarry limits to ensure all available rock is extracted and put to use). Beyond the establishment of narrow and shallow littoral zones some research and experimentation have been completed globally, testing the creation of artificial islands to serve as floating habitat on these deep bodies of water.

The idea of Artificial Floating Islands (AFI) was originally developed as fish spawning reefs in 1950s. These features are floating structures on which aquatic vegetation such as reeds grow. In addition to providing habitat, some AFIs were constructed to protect shorelines by wave absorption. The AFI technology is reported to have experienced more recent interest and has been tested in applications in Japan, Germany, and U.S.A. About 15 companies have installed approximately 2,000 artificial floating islands, with the largest reaching 24,000m2 (http://www.pwri.go.jp/team/rrt/eng/img/report/contentnew2.pdf).

Active rehabilitation was taken even further under similar circumstances near Madrid, Spain, where Hanson-owned gravel pits were converted to wetlands consistent with historical Jorma river wetlands and agricultural lowlands (UEPG 2009b). Seven lakes were deliberately constructed, including islands and beach areas sheltered from strong winds typical of the region. Almost 6000 native plants were introduced and lakes were stocked with fish; combined these efforts led to rapid wetland development, recovered important agricultural lands, and yielded site operators first prize in the "Restoration" category of the 2007 ANEFA's (Spanish acronym for Spanish National Association of Aggregate Producers) National Sustainable Development Awards.

## 2.3 Woodland Habitat Features

Rehabilitation of dry quarries in Spain to ecologically important Mediterranean woodlands and grasslands – including montane and rock outcrop ecosystems – has been successfully achieved on several occasions as a result of intensive, carefully-planned restoration efforts. Two outstanding examples from Malaga province include a Holcim quarry known as the Isabel Concession Project, and Italcementi Group's Los Arnales quarry. Both of these operations won prestigious rehabilitation awards from the European Aggregate Producer's Association (UEGP) (UEPG 2005, 2007). In both cases the major problem faced was the tremendous height of the 60-100 m quarry face. This required controlled blasting and earthmoving to create a large series of stratified terraces, composed of short lifts and narrow benches that were subsequently covered with topsoil.

At the Isabel Concession Project the focus of all plantings was pine trees while at Los Arnales a mixture of native trees, shrubs, herbs and grasses was planted. In the latter case, the decision of what to plant was based on comparison of microhabitat conditions found in the quarry versus those observed in surrounding mountain ecosystems. Part of the success of plant communities was likely due to the construction of nursery facilities on site, which enabled necessary hardening-off (pruning the root ball) prior to out-planting. However, drip irrigation systems were required to maintain the planted communities. At both sites vegetation flourished, including species planted specifically to attract birds and mammals. Additional measures taken to provide refuge for wildlife at the Los Arnales site included installation of drinking troughs in strategic areas, and the creation of rabbit warrens. At the Isabel Concession Project, particular effort was taken to reduce visual impacts of the quarry on the landscape by using rock removed in terrace creation to create visual as well as safety barriers.

### 2.4 Other Habitat Features

At a Lafarge site in Venezuela, a quarry was successfully rehabilitated despite intense local wind and drought conditions (Lafarge 2009e). Problematic steep, unstable slopes at the site were improved by reformatting quarry walls into a series of stable benches, which were amended with organic soils and planted with 10 species of native plants adapted to local conditions. Vegetation was propagated efficiently within a greenhouse built on-site and capable of providing 5000 native plants per year for out-planting. Minimization of slope erosion through creation of stormwater management and drainage structures was critical to successful rehabilitation in this region. Construction of drainage controls from natural materials including stone and wood contributed to rehabilitation success by improving the ease with which they could be maintained over the long term.

Finally, demolition wastes were used to replicate an esker of high cultural as well as ecological value in a Stockholm, Sweden gravel pit (Morfeldt 1993).

### 2.5 Multiple Land Uses and Innovative Partnerships

In the United Kingdom many extraction sites have been exceptionally rehabilitated, thanks in part to the “culture of sustainability” that has emerged in British extraction industries in response to high demand for land, strict environmental regulations, and strong public desire for environmental accountability along with openness on behalf of all the stakeholders to partnerships. One mark of this culture is the competition for coveted prizes awarded to outstanding rehabilitation successes, such as the Cooper-Heyman Cup, awarded annually by the U.K.’s Mineral Products Association (MPA).

In 2008 this prize went to Hanson Aggregates’ Otley Quarry in Bridge End, Otley, a 50 ha sand and gravel pit that was converted into a mosaic of ecosystems to achieve multiple goals, including nature conservation, agriculture, and amenity (Heidelberg Cement 2009d). Lakes were created on-site as fish and waterfowl habitat, as well as for recreational fishing and sailing use. Substrates dredged from lakes were applied to drier portions of the quarry to build soils suitable for agricultural grasslands, as well as wet grasslands, alder carr woodland, oak-ash woodland, and species-rich hedgerows. Shallow gradients were created at the edges of the lakes for the construction of reed beds - nesting sites for terns and plovers, and also important structures for the water-filtering capacity of wetlands. Furthermore, small islands were created in the lakes and covered with shingles to provide resting areas for waterfowl. This wide variety of habitats was created while extraction was ongoing; when extraction was completed much of the area was already colonized by desired vegetation communities and diverse wildlife, ranging from 144 species of birds sighted, to deer, otters, badgers, and small mammals. Hanson partnered with the Otley Wetland Nature Reserve Trust and Leeds City and Otley town councils to create the Otley Wetland Nature Reserve. Access is available to permit holders available from the Nature Reserve Trust for a nominal annual fee.

An example of partnerships is found at the restoration of Whisby Quarry in Lincolnshire by Lafarge Aggregates which followed a period of natural colonisation of the extracted lakes and included entering into a longterm lease with the Lincolnshire Wildlife Trust (LWT). The resulting "Natural World Project" was opened to the public in 2000 and includes: (1) a Nature Park that is managed by LWT, of which the majority (152 hectares) is now held in 125 year leases or owned by the partner organisations including several compartments from Lafarge. The Park includes lakes, woodlands, ponds, scrub, grassland that collectively provide habitat for variety of wildlife. A small flock of Hebridean sheep are used to control the vegetation in various habitats on the site; (2) The Natural World Centre which is a visitor centre managed by the local Council and includes an interpretive centre and a large exhibition gallery focused on the impact of human beings on the earth and the use of natural resources; and, (3) the Lafarge Education Centre that is also managed by the LWT, and provides both a classroom and laboratory facility. The Park was designated as a local nature reserve by English Nature in 2002 (David Park, per. comm., September 18th 2009).

A similar example of a pit that is still operating is the Paxton Pits owned by Bardon Aggregates, parts of which are now a Local Nature Reserve (LNR) thanks to an agreement between the Huntingdonshire District Council (HDC), English China Clay (now Aggregate Industries) and Redland Aggregates (now Lafarge Redland), conservation organisations, and water and sports angling groups. Local birdwatchers provided 6,000 records which formed the basis for parts of the Paxton Pits being designated as a Site of Special Scientific Interest (SSSI) in 1986. The LNR now includes a visitor centre sponsored by Redland Aggregates. In 1995, the Friends of Paxton Pit Nature Reserve was established and it supports a volunteer warden service, promotes the LNR, and organizes many fund raising initiatives. Visitors now number over 100,000 per year and the LNR is now professionally staffed. Aggregate Industries is continuing to extend their sand and gravel extraction and this is viewed as an opportunity to markedly increase the size of the LNR overtime (http://www.paxton-pits.org.uk/reshist.htm).

Other UK examples of high-quality rehabilitation to natural heritage landscapes include Hanson's Irthlingborough Quarry and Lafarge's Cauldron Cement Works, both of which won Restoration Awards in 2009 (Mineral Products Association 2009). Irthlingborough Quarry, located in Northhamptonshire, within the floodplain of the River Nene, was mined extensively for sand and gravel and rehabilitated to a significant wetland site that provides prime habitat for diverse and threatened waterfowl species, as well as dragonflies, amphibians, badgers, and other fauna. The site has been proposed as a RAMSAR site and Special Protection Area because of its value to wildlife. The landform of the site was specifically designed to create a wide variety of habitat conditions, ranging from deep open water, to created islands, species-rich flood meadows, and wet woodlands. In addition to providing wildlife habitat, these landforms functioned to maintain a high flood-retaining capacity at the site and thus improved the stability of surrounding regions. Although Irthlingborough Quarry is primarily a nature area, the site is open to the public for hiking and fishing use, with a series of footpaths strategically created to balance accessibility with conservation.

In contrast, the Cauldron Cement Works in Staffordshire is a large slate quarry featuring considerable dry land in addition to water bodies. The rehabilitated sites now included lakes with gently-shelved shores for reedbed development, and on a former spoil heap two distinct habitats are provided: pasture land, and a "post-industrial biodiversity area" featuring a wide diversity of grass and wildflower species – many characteristic of hay meadows – that have naturally colonized the slate waste. Such combinations of landscape-creation and spontaneously-assembling ecosystems are typical of the most successful rehabilitation projects in the UK.

A South American example of successful quarry after-use as a natural heritage area comes from a Cemex-owned quarry in Columbia (Cemex 2009b). The quarry has recently been converted to "La Fiscala Private Ecological Reserve", an area that now provides essential green space to an urban area of approximately one million people. The terrain of the site was designed to produce favourable habitat for diverse local plant species, which were in turn propagated at a nursery near the site, where they were acclimatized to field-like conditions prior to out-planting in the quarry. Successful revegetation has provided important shelters to migrating bird species, and the rehabilitation has contributed significantly to the biodiversity of the region.

## 2.6 Creation of Natural Heritage Landscapes - Individual Species

The above sites all illustrate the objective of providing habitats of conservation interest. At other sites, individual species are the rehabilitation target as discussed below.

The Sand Martin, designated on Germany's red list of endangered species and protected under the Federal Nature Conservation Act, once bred on the riverbanks of many of the rivers of central Europe. The straightening of many of these watercourses eliminated much of their natural habitat. The species now regularly breeds in sand and gravel pits, preferring the combination of loose soils and steep slopes. In response, Heidelberg Cement has established the "Species Protection Program Sand Martin" at 42 of its sites in Germany. The Program sets out a series of steps, including the identification of existing conditions, the development of a management plan, and finally a monitoring plan all aimed at minimizing potential conflicts between mineral extraction and the protection of the species and its habitat. Measures such as breeding surveys to identify individuals and nesting holes are undertaken and mapped. If areas that are currently used for breeding are slated for extraction, they are worked during periods when they are not occupied and compensatory habitats are created in adjacent areas (Heidelberg Cement 2009e).

For a number of years a group of migratory sand martins had occupied a limestone quarry - Frasnes Quarry - in the Fagne Basin of Belgium. As in Germany, the sand martins are in decline in Belgium, so the company, Carmeuse, undertook a pilot project with the "Les Bocages", an association for nature conservation. This project included the creation of a new artificial cliff in another part of the site, and the martins were diverted from the original site through the use of aluminium foil strips and attracted to the artificial cliff through the use of tape recorded calls and constructed tunnels. This initiative resulted in a colony of 80 pairs occupying the new cliff, and the artificial cliff face is routinely maintained to prevent the clogging up of the holes. Martins have nested every year and 377 pulli have been banded, and this colony of sand martins is now the largest in Belgium. This project has not only engaged the quarry workers in ‘their’ birds but has also translated to an interest in other forms of fauna and flora on the quarry, including rare Great Horned owls. The project has also been awarded the Eurosite Award 1993 “Creation of New Habitats” (European Aggregates Association 2009).

In the United States successful rehabilitation to a “natural” landscape, compatible with surrounding agricultural and residential land uses, is exemplified by Heidelberg Cement’s Nokomis Quarry in Illinois (Heidelberg Cement 2009c). At this site agricultural land with little topographic variability had been mined for limestone and ended up as a large open pit. Progressive rehabilitation involved establishing rough grades on mined cuts at the time of extraction, followed by sowing of pasture grass and herb species, nitrogen fertilizer, and quick-growing oat grass to provide initial soil stabilization. The end product of the grading was a series of gently-rolling hills compatible with grazing and wildlife sanctuary, and low wet valleys for stormwater retention. A deep retention pond was created within a previously-abandoned mine-cut at one end of the site, with the secondary goal of providing refuge for fish species. The cut was cleaned while still dry, and brush was either pushed into piles to create fish habitat, or levelled to provide spawning areas. Permanent flooding of the cut then followed, and eventually so did colonization by aquatic fauna.

Overall, the conversion of the landscape from flat, dry, agricultural land before extraction to a topographically diverse mosaic of dry and wet pasture lands after extraction increased the biodiversity capacity of the entire region, by providing foraging, nesting, and corridor habitat to diverse wildlife, and by preventing negative flood impacts in surrounding areas. The value of the project was acknowledged formally when Nokomis site operators won the Illinois Department of Natural Resources Reclamation Award in 2008.

A contrasting example from the Unites States illustrates a less-conventional rehabilitation project, still underway, that has high potential to provide exceptional wildlife conservation habitat. A 155-acre Lafarge gravel pit in Elton, New York, was originally scheduled for rehabilitation to corn agriculture, but the high expense of the topsoil required to support this crop concerned operators. An alternative plan was forged that was at once cost-effective and promised high returns for biodiversity conservation (Meyers 2006). The proposal was to grade the site and spread accumulated overburden along with minimal topsoil, in such a fashion as to create ideal habitat for nationally threatened butterfly species, including the Karner Blue and Regal Fritillary butterflies. To achieve stable populations, Karner Blue butterflies require at least 100 acres of dry savannah habitat that features warm-season grasses and wildflowers such as the Blue Lupine, for nectar resources and egg-laying habitat. In contrast, the Regal Fritillary requires wet meadow species such as birdsfoot violet.

To create conservation habitat for these species, portions of the site above the water table have been planted with diverse native warm-season grass species, blue lupines and other wildflowers, and characteristic savanna tree species, such as oaks and a blight-resistant variety of American Chestnut. Once extraction is complete at the site, settling ponds and other areas mined below the water-table areas will be flooded and converted to wet meadow planted with birdsfoot violets. As a safety precaution against bush fires demolishing the butterfly habitat, unvegetated or wet "firebreak" areas were established, dividing the Karner Blue habitat into several distinct patches among which butterflies but not fire could traverse. To date initial establishment of the warm-season grass savanna has been successful, but lupine establishment needs further assistance. Impressively, the cost of this rehabilitation strategy is estimated to be only about one-third that of converting the quarry to a cornfield. A stream coursing through the site additionally provides high-quality habitat for various fish species including trout. Recognizing that such environments integrate best into surrounding human-dominated landscapes when they are appreciated by the public, operators have established footpaths and a small parking lot on site, and recreational fishing is encouraged in designated segments of the stream.

At extraction sites in Canada, and in Ontario in particular, examples of best-practice rehabilitation to natural heritage landscapes are similar to some of the examples found in other geographic regions. Many examples can be found of lakes and ponds created during aggregate extraction that provide habitat for fish and waterfowl, however, creative reconstruction of more complex landforms including wetlands has been rare. Three examples are the simulation of Niagara Escarpment landforms and ecosystems at Dufferin Aggregates' Milton Quarry

(Zimmerman and Lowe 2001, 2006, Lowe and Zimmerman 2004), and the development and conservation of diverse wetland habitats in Wainfleet (OSSGA 2009) and Snyders flats in Waterloo owned by the Grand River Conservation Authority. The highest rehabilitation honour awarded for rehabilitated sites with public ownership or access by the Ontario Sand, Stone, and Gravel Association (OSSGA) – the Bronze Plaque – has been granted 18 times since its inception in 1976, but only three of the recognized projects had natural heritage components (OSSGA 2009).

On the horizon in Ontario is the potential to employ quarry rehabilitation to the preservation of alvar ecosystems – glacially-formed limestone pavements that support consistent and highly diverse biotic communities including rare and threatened grass, wildflower, dragonfly, butterfly, and bird species. Conserving alvar biological and geological diversity is a high priority in Ontario, and limestone quarry floors may provide an ideal environment for such conservation, even if alvar habitat had never existed at a particular location prior to quarrying. This opportunity is an outcome of the close environmental equivalence of dry quarry floors to alvars, as demonstrated by the spontaneous colonization of old quarries by species normally confined to alvars (Tomlinson et al. 2008), and by the capacity for such species to thrive on quarry floors following seed addition alone, with little dependency upon substrate amendments (Richardson et al. 2009).

## 3.0 AGRICULTURAL AFTER-USES FOR REHABILITATED EXTRACTION SITES

Rehabilitation to fields or orchards for agricultural production can sometimes be a viable after-use for aggregate extraction sites. Rehabilitation and long-term operational costs are generally more expensive for agricultural after-uses than natural heritage, but over time successful crop yields can offset this cost. The decision to return to agriculture is often dictated by land-use policy rather than by the aggregate producers themselves. This decision can reflect a desire to rehabilitate to a productive state compatible with historical or regional agricultural landscapes, and to maintain the important local and regional capacity for food and wine production. In some cases, agricultural production is combined with conservation goals. Considerable efforts may be made to foster biodiversity conservation, recreation, and spontaneous ecosystem development alongside agricultural production, enabling diverse land uses to interact in complementary ways.

The rehabilitation of Heidelberg Cement's Romont Quarry in Belgium illustrates several of these points (Heidelberg Cement 2009b). The 220 hectare site is located within a region where 80% of the landscape is devoted to agricultural production, and the return of the chalk quarry to high-quality agricultural land was requested by the Belgian government even before extraction began. It was thus agreed from the outset that following aggregate depletion, the site would be rehabilitated to an agricultural landscape of equal or greater quality than that which existed prior to extraction, and that this land would be given back to farmers. However, it was also a goal to maintain some of the ecologically interesting environmental features that has evolved during the extraction process, such as cliff faces and wet or sandy habitats for species of conservation interest, including the Little Ringed Plover, Northern Lapwing, and Natter Jack Toad. These goals were achieved by returning most of the open dry areas of the quarry to agriculture, but leaving other features such as wet drainage areas and exposed cliff faces untouched.

Return of the quarry floor to arable land required several steps. First large parcels of floor were cleared and a one-metre deep bed of flint was constituted. This bed was then covered by quarry spoils, which were spread flat and compacted by bulldozers. Topsoil was then imported and spread evenly across the compacted spoil layer using lighter equipment, creating a layer 30 cm deep. These processes required creation of a network of drainage ditches, as well as vehicle pathways to prevent over-compression of substrates. Fields were ploughed and seeded with a mixture of Ray Grass and Red Clover, as fallow crops to improve soil structure and nutritional value. Moderate additions of Kieserite and various composts were added to amend soil pH, magnesium, and organic matter content. Fallow crops remain on the site presently, but will soon be turned to crop development. Finally, in addition to agricultural, cliff, and successional habitat on site, woodland grove structures are being created throughout the site to provide refuge for wildlife, among other functions.

Several examples of effective rehabilitation from extracted land to agriculture come from the UK; many developed near areas of high population, such as the city of London where agricultural land is at a premium and crops highly valued. Perhaps the best current example is the case of Laleham Farm, near Middlesex, England (Mineral Products Association 2009). Laleham farm successfully produces nine high-value market crops such as fennel, kohl rabi, coriander, and spring onion, on a site that was simultaneously mined for sand and gravel throughout much of the farm's existence (presently owned by Brett Aggregates). This complementary coexistence of farming and aggregate extraction was made possible by careful planning and progressive rehabilitation measures especially for soil mangement. For example, soil properties were monitored before and during extraction, and the particular properties of a substrate dictated where and how it was stored. Immediately upon completion of extraction in an area, particular soils were reintroduced in a manner that was beneficial to crop establishment, enabling resumed crop production within 18 months of extraction ending.

At the same time, goals of biodiversity conservation were also being met, though measures such as planting wide hedgerows to serve as species-rich wildlife corridors, and creation of a small lake to serve as refuge for waterfowl, dragonflies, and amphibians. Both rehabilitation and farming practices actively create habitat for the conservation of threatened bird species including Lapwings, Skylarks, Little Ringed Plovers, and Yellow Wagtails. The sand and gravel pit rehabilitation measures employed at Laleham Farm earned site operators a special 40th Anniversary MPA award that acknowledged the farm as the most successful case of rehabilitation since the Mineral Products Association formed.

Other UK examples of successful rehabilitation to agriculture combined with conservation include the Tarmac-owned sand and gravel pit near Norfolk known as “Hell Pit” (Mineral Products Association 2009), and the Lafarge “West Deeping” quarry in South Lincolnshire (Lafarge 2009b). At Hell Pit, creation of agricultural land was balanced with development of woodlands, wetlands, and bodies of open water. The aquatic habitats attract diverse wildfowl and are inhabited by many fish species (public fishing is welcomed by the landowner), while woody areas that were established using shrub, tree, bramble, nettle, and wildflower species provide excellent habitat for game species. Agriculturally, the site is primarily used for grazing by highland cattle.

Finally, the Lafarge West Deeping quarry is similar to other arable farmland rehabilitation projects with the exception that particular drainage measures were needed as a result of a water table lying only one metre below the surface of the site. To account for potential periods of flooding, Lafarge created a carefully-designed network of drainage channels to divert all runoff to a single lake in one corner of the quarry; this lake was then actively pumped as needed (with excess water discharged to a nearby stream) to maintain stable mesic conditions in grain fields established on site. The restoration process included the use of all soil-like materials excavated during the sand and gravel extraction as the ‘lower subsoil’ to augment the existing thin subsoils thereby improving the soil depth and quality as compared to the original profile (David Park, per. comm., September 18, 2009).

In addition to the preservation and enhancement of semi-natural vegetation, the restoration of Lafarge’s Dinmor Quarry on the Isle of Anglesey includes a fish farm, operated by the Bluewater Flatfish Farms Limited, that represents the ‘state of the art’ in modern fish farming technology. The farm created 7 jobs and produced 200 tonnes of turbot in its first year of operation, with an aim of increasing production to 500 tonnes per annum (David Park, per. comm., September 18, 2009).

Another example of fish farming also comes from the U.S., but similar uses can be found in most jurisdictions. In mountain ranges of northeastern Minnesota numerous abandoned rock quarries and deep iron-ore pits have become flooded lakes; and several of these lakes are now managed for aquaculture (Axler et al. 1998). Salmonid species are stocked, bred, and raised in net-pens established in portions of the lakes. While waters can become moderately contaminated with nitrogenous wastes from fish production, providing artificial aeration and allowing ponds to lie fallow for periods seems to largely control these problems and promote successful fish-rearing.

The Walleye Fishermen of Ontario have entered into an agreement with James Dick Construction and the Ministry of Natural Resources to culture fingerlings for government restocking and rehabilitation purposes. James Dick allows the group at no charge to raise walleye in their Caledon pit where eight isolated groundwater-fed ponds are found.

An example of another different type of crop produced at a rehabilitated quarry comes from Lafarge’s Karsdorf Cement plant in Germany (Lafarge 2009). The site, located in the middle of a wine-growing region, was scheduled for rehabilitation to several types of ecosystems, with one particular interest being the production of grapes for wine-making. Thus, while some portions of the quarry were converted to forest, one portion was converted to a vineyard. Limestone and appropriate topsoil were introduced to a 3.6 ha area on the quarry floor to prepare the soil, then grape vines were planted and fences were erected to keep wild animals out. Remarkably, within two years of vine-planting the first batch of wine was produced and reviewed positively by critics and consumers.

Cemex planted 26 ha of grapes at their Yepes Quarry near Toledo, Spain. They have been producing Syrah, Merlot and Cabernet Sauvignon vines for the last five years, and are producing 90,000 bottles a year under the name Vina Canterana (Carolyn Loder, per. comm., October 12 and October 23, 2009).

Rehabilitated extraction sites may be managed to provide "crops" beyond grains, vegetables, herbs, and pasturelands of traditional agriculture. Agroforestry, the cultivation and harvesting of particular tree species for human use rather than nature conservation or timber, is one such option. In California, walnut and almond orchards have been grown successfully on gravel pits carefully levelled and prepared for the orchards.

Often such operations are monoculture plantations of one or a few species, selected to optimally balance tolerance for harsh physical conditions with physiological or ecological properties for human use. Examples include hybrid Aspen plantations established at both reclaimed oil shale and calcareous quarry sites in Estonia (Tullus *et al.* 2008), and establishment of three Eucalyptus species at a Holcim cement plant in Morocco (Holcim Ltd. 2009b). In this second case a chief value of the crop selected was the capacity to sequester carbon dioxide within soil and plant biomass. As carbon dioxide is emitted during many stages of aggregate production, rehabilitating extraction sites using species with high carbon-fixing capabilities can promote greater operational sustainability overall with respect to slowing climate change.

In Ontario, rehabilitation to agricultural use is relatively common, as it is required by provincial policy when extraction takes place on prime agricultural or tender fruit areas. It occurs more frequently in gravel pits than rock quarries. The approaches employed have required standard practice for land shaping and soil management, with special conditions for tender fruit, (Lowe 1984), and are generally in keeping with practices in Europe and the USA.

Successful examples of agriculture-directed rehabilitation in Ontario include Capital Paving's "Pit #2" in Puslinch Township, where gravel workings were converted to hay production and livestock grazing within 10 years of extraction *beginning* on the site. This site received OSSGA's Outstanding Achievement in Property Rehabilitation award in 2003 (Sherry Yundt, pers. comm., 2009). Research on this site has shown that agricultural production has increased since aggregate extraction. The former James Sabiston sand and gravel pit in the town of Whitchurch-Stouffville located on the Oak Ridges Moraine was rehabilitated to a mosaic of rolling pasture lands and ponds, and is presently used for horse-farming. Lafarge's Fonthill Pit in Pelham on the Fonthill kame in the Niagara Region is an example where portions of the site have been rehabilitated to pear, peach, plum, and sour cherry orchards, and Vineland Quarries that was converted to a productive vineyard in the Niagara region (OSSGA 2008). Some of these sites, amongst others are illustrated in OSSGA's About Aggregates Brochure #3, Rehabilitation of Pits and Quarries, attached as Appendix A.

## 4.0 RECREATIONAL USES OF REHABILITATED EXTRACTION SITES

Extraction sites provide opportunities for a very wide variety of recreational after-uses, ranging from ecotourism and outdoor nature activities to organized sports and artistic endeavours.

Rehabilitation taken at Cemex's Eversley Quarry in Hampshire, England, combines recreation and conservation land uses. The site is located on land that was primarily river meadow prior to large-scale excavation of sand and gravel. Rehabilitation involved careful planning, in association with local authorities and community groups, to ensure that as many interests were met as possible. As a result, four key areas were created at the rehabilitated "Blackwater Valley Leisure" site (Cemex 2009a). In addition to an outstanding nature reserve and hiking area featuring riverine, wetland, and meadow habitat, a 9-hole golf course and 30-bay driving range were built on the site, using land corresponding to the earliest settlement ponds created during extraction.

Golf facilities are particularly impressive both aesthetically and ecologically due to interesting natural features created during quarrying, such as open cliff faces, which were maintained and incorporated into the rehabilitation design. Elsewhere at Blackwater Valley Leisure site athletic playing fields were built, offering soccer, cricket, and hockey facilities to the local community. Plans are in place to create more sporting facilities, for which usage rights will be leased to a local sports association at no cost. Boating and waterskiing are offered on the three lakes and connecting waterways that have been created at the quarry site. The balance of nature conservation, recreation, and community-building facilitated at this site earned site operators the Mineral Products Association's Cooper-Heyman Cup in 1997.

In Australia, the Penrith Lakes Scheme provides an excellent example of sophisticated rehabilitation planning that attempts to focus on a diversity of after uses with active and passive recreation as the primary after use objective, resulting from a 10 year preplanning process that included extensive assessment of numerous alternative possibilities. The choice of a primary after use for active and passive recreation and tourism was finally selected over a less expensive wetland creation, as a result of the community and government goals. Also included in the after uses are: conservation, water management, aboriginal and cultural heritage preservation and education, and future residential and employment land. The nearly 2000-hectare sand and gravel extraction site is scheduled to be depleted in the next five years, but comprehensive after-use planning and development has been underway for 30 years, as the three aggregate production companies working the site formed a partnership corporation to plan, implement, and eventually profit from aspects of the multi-faceted rehabilitation project (Carter et al. 1994, Penrith Lakes Development Corporation 2009). To ensure that community needs and desires will be met optimally, the developers have been working closely with a Community Advisory Committee featuring a broad spectrum of people representing the community which will eventually be making use of the site. While it is hoped that development will involve residential and commercial construction, these plans appear to be stalled currently, while the industry partners review the planning and design requirements. This project is discussed further in Chapter 8 as a case study for Comprehensive Rehabilitation Plans.

The Penrith Lakes project is probably the most ambitious anywhere in the world, and the success of the active recreation planning was illustrated when the site was used for the 2000 Summer Olympic venue for rowing and white water sports (Yundt and Lowe 2002). These active recreation areas will be balanced with large and integrated areas reserved for conservation and recreational uses as well as water management. Prominent among these are the multiple extraction-pit lakes on site. These lakes are already developing into sanctuaries for fish, waterfowl, and other wildlife, but soon will be incorporated into recreational uses ranging from hiking and fishing to swimming, boating, and other watersports.

Numerous examples of recreational lakes at former extraction sites can be found elsewhere in the world, including Lake Fuhlinger in Cologne, Germany (Jobgen et al. 2004). Ontario examples with active water based sports include Sherkston Beaches in Niagara, St Mary's quarry in the Town of St. Mary's (municipally owned) and the Elora quarry in Wellington County (owned by the Grand River Conservation Authority), both very popular swimming areas. Other examples in Ontario include quarries in the Greenbelt that have been rehabilitated to conservation use and now function as public recreation areas or will be in the future ( Lowe and Yundt 2008, Zimmerman and Lowe 2006).

Finally, James Dick Sand and Gravel in Caledon entered into an agreement with the Canadian Cross-Training Club and the site is opened up to the members who in turn run a camp for children using one of the lakes for part of the activities, in addition to running regular training sessions in the lake.

**Figure 4 – James Dick Sand and Gravel: Cross – Training Club**

**Figure 5 – James Dick Beach Sign**


Occasionally this same site is used for filming, with the most recent being a CBC movie filmed in August 2009 (Figure 6).

**Figure 6 – CBC Filming at James Dick Sand and Gravel**

There is considerable historical precedent for rehabilitation of depleted gravel pits or quarries to botanical or horticultural gardens, offering pubic recreation and education and industry; botanical gardens are beloved by tourists, can be economically profitable. Here it is mainly the landscape value of the excavated pit or quarry landform that currently provides the attraction, especially with presence of cliffs, which provide a dramatic backdrop to the demonstration plants. Although not currently targeted, a high diversity of appropriate species could be maintained in botanical gardens on human-excavated rock outcrops such as old quarries, where ideal conditions are provided that would be difficult and expensive to recreate in a more conventional environmental context.

Several Canadian examples of successful botanical gardens established within rehabilitated gravel pits or quarries include the Rock Garden area of the Royal Botanical Gardens in Burlington, Ontario (a former sand and gravel pit); Buchart Gardens in Victoria, British Columbia (a former limestone quarry and cement plant); Queen Elizabeth Gardens in Vancouver (a former stone quarry); and the Botanical Gardens at Memorial University in Newfoundland.

Globally, important examples include the small scale examples such as the Quarry Garden at Scotney Castle in Kent, England, located within the workings of an 18th century sandstone quarry, where the rugged background of the quarry faces fit with the Picturesque period of garden design in the Victorian era; the Eden Garden in Auckland New Zealand where an old basalt quarry was extensively landscaped to establish a terraced memorial garden (Lowe and Yundt 2007), the extensive educational gardens and biospheres associated with the large Eden Project in Cornwall, England, at the site of a former china clay pit (Smit, 2001) and the book Eden by Tim Smit 2001 ) ; and Penang Botanic Gardens, in George Town, Malaysia (a former granite quarry). Finally, at a still-active Holcim cement plant in Misamis Oriental, the Philippines, both an orchidarium and a butterfly garden have recently been established, to the benefit of the local community and regional tourism (Holcim Ltd. 2009).

Rock-climbing, a quickly growing recreational sport world-wide, requires steep slopes and open cliff faces to challenge climbers at varying levels of skill. While there is concern that rock-climbing within pristine natural cliff ecosystems may damage the rare biological communities assembled there, slope and cliff faces evolved during rock quarrying can sometimes provide a suitable analog for rock-climbers (Thiel and Spribille 2007). Note however that faces exposed during quarrying are often unstable, fracturing easily and providing generally dangerous substrate for sport climbing; in fact in some public recreational quarries, the foot of cliffs is fenced off for safety reasons (e.g. Halswell quarry in Christchurch).

Adrenalin Quarry in the United Kingdom incorporates a range of adventure racing including zip wires, high-speed hovercrafts, and go karting. The zip wires take advantage of the created cliff face, while the low-flying hovercrafts operate in the flooded base of the quarry (http://www.adrenalinquarry.co.uk/).

Located in East Anglia, "Snoasis" is planned to house the largest indoor ski slope in Europe and to offer a total of 14 different winter sports programs. This innovative use of the former Blue Circle Cement works, known as Mason's quarry, will take full advantage of the features of the quarry. The site not only aimed to provide a facility for training athletes but is also aimed at maximizing its attractiveness as a tourist destination (http://www.snoasis.co.uk/snoasis/?q=intro).

The Los Angeles Landfill, located northeast of Albuquerque New Mexico, was formerly a sand and gravel pit and then became the launch site for the Albuquerque International Balloon Fiesta (AIBF) from 1984 to 1995 – the largest balloon event in the world. The site is still used as an RV parking facility during the AIBF (Carolyn Loder, per. comm., October 12 and October 23, 2009).

Creation of playgrounds and athletic fields at former mineral extraction sites has been a popular after-use for such sites in Ontario, with award winning examples including Smythe Park in Toronto and the Hagersville Ball Park in Hagersville (OSSGA 2009). Such past rehabilitation efforts have been relatively well documented (Yundt and Augaitis 1992).

Successful golf-course development at former Ontario extraction sites has resulted in the OSSGA Bronze Plaque being awarded to the Peninsula Lake Golf Course in Fonthill; Eden Park Gardens in London; Oaks Golf Course in London; and Orchard View Golf Course in Leamington (OSSGA 2009). As with other after-uses in Ontario, clear efforts to link recreation and conservation have been lacking. Construction of golf courses at such sites, while very successful, has similarly missed valuable conservation opportunities presented by golf courses (Terman 1997).

Global examples of effective conversion of aggregate extraction to golf courses include the Acropolis Golf Project, in the suburbs of Como, Italy (UEPG 2005). This site included both sand and gravel pits and a hard rock quarry that not only posed the typical problems associated with barren, mined sites, but additionally had been illegally used for disposal of dangerous industrial wastes. Cooperation between the aggregate company Consorzio Comense Inerti Spa and the Como Health Service enabled successful reclamation of the site via land-filling with construction and demolition waste, followed by necessary land-shaping, topsoil replacement, and plantings. For the success of this partnership in creating an outstanding golf course and natural area, a UEGP Sustainability Award was granted in 2005.

Nene Park emerged as a by-product of the expansion of the Town of Peterborough in the United Kingdom. The need for a greater number and wider range of sports facilities was identified early on in the planning process by the City, and so a large park stretching along the river valley close to the city centre was incorporated into the Master Plan. Initially, the lands were leased to Amey Roadstone to extract sand and gravel for use in the construction associated with the expansion of the town. The Park was officially opened in 1988 and is managed by the Nene Park Trust and incorporates a series of lakes, woodlands, and meadow lands, in addition to picnic areas, rowing and fishing facilities.

Above and beyond applications to athletics, sports, and ecotourism, there is considerable opportunity for pit and quarry after-use to benefit the arts by providing unique environments for concerts, theatre, art exhibitions, and even creation of landscape-scale art. A striking example of successful linkage of quarry geology, commercial industry, and musical arts is the 3000-seat amphitheatre in Ratvik, Sweden, known as “Dalhalla”. This amphitheatre was developed within the hollowed-out confines of an ancient limestone quarry, and is renowned by artists and music fans alike for its exceptional sound quality, as well as its stunning visual beauty (Dalhalla 2009). The site is currently the home of an opera festival of international talent, and has been a commercial success for site operators.

At a smaller scale, in the Burgundy region of France an old quarry was converted into an outdoor theatre for dramatic productions (Holcim Ltd. 2009a). Stone extraction on site had been terminated in the 1930s due to community frustration with dust and noise pollution; Holcim Ltd. acquired the site in 1999 with the intent of initiating excavation in another section, but first needed to garner public support. Following meetings between the aggregate industry and members of the local community, it was decided that extraction would be allowed provided that a theatre was constructed in the old portion of the quarry. A 430-seat theatre was built using a design complementary to the original quarry landform, and the site is very popular with townspeople and tourists alike for its productions and visually interesting features.

Opened in the 1850s, extraction of the Halswell Quarry near Christchurch continued until 1990 and is considered to be the oldest continuously operated quarry in Australia. The Quarry has now been rehabilitated into a large park with various amenities, including a popular walking trail around the rim of the quarry with historical plaques explaining the industry. At Easter there is a service within the quarry itself, using the amphitheatre formed by the steep, jagged walls of the quarry.

Other artistic uses of former extraction sites include an 140-kilometre diameter earth sculpture entitled “Broken Circle” created by artist Robert Smithson in a sand pit in the Netherlands, and a large earth sculpture of concentric terraces called “Untitled (Johnson Pit #30)” by Robert Morris in King County, Washington. In Woodstock, New York an old quarry known as “Opus 40” was sculpted by Harvey Fite to produce geometric forms resembling a hard-rock Italian garden, and functioning as ramps, pools, steps and terraces. While such sites may include prominent and permanent artistic works, they represent successful rehabilitation because they provide refuge for human culture.

The National Memorial Arboretum (NMA) and the National Forest resulted from the transfer of land at Alrewas Quarry by Lafarge who continue to be a trustee of the NMA. The NMA is a war memorial and consists of a combination of over 60 hectares of wooded parkland – the National Forest – and a visitor centre, chapel, Armed Forces Memorial and over 50 remembrance and memorial gardens – the National Memorial Arboretum. The facility not only exemplifies an innovative form of rehabilitation in terms its primary mandate as a commemoration to those who have served in wars, but also contributes significantly to education, wildlife habitat, and community involvement.

One emerging trend in the southwestern United States is to look to rehabilitated pits and quarries to meet sustainability objectives by incorporating solar panels. These initiatives often require large tracts of land, something that is frequently in short supply and pits and quarries present an interesting opportunity to meet this need (Carolyn Loder, per. comm., October 12 and October 23, 2009)

## 5.0 DEVELOPMENT USES OF REHABILITATED EXTRACTION SITES

A great diversity of after-uses for former aggregate extraction sites directly benefit the development of human societies through further development, especially in urban areas. These include everything from providing appropriate spaces and structures for the disposal of waste products, to enabling control of water resources at the regional scale, to serving as a foundation for the construction of houses, schools, and marketplaces. Often geological and environmental properties of extraction sites influence the nature of the developmental land-use.

Given the serious and global problems of increasing solid-waste production by humans and decreasing waste-storage capacity, the rehabilitation of depleted extraction pits and quarries for waste landfills is logical and has at least some potential for solving local and regional waste-management problems, provided there is proper environmental/engineering design to avoid down stream environmental impacts. Also of concern are affects of geotechnical instability at extraction sites used for waste storage, on both waste-management operations and on surrounding ecosystems (El-Fadel et al. 2001).

Careful assessment of an extraction site's geological and hydrological properties, including geotechnical stability and groundwater security, is thus required prior to after-use as a landfill. Many examples of such assessments can be found in the environmental science and engineering literature, and while occasionally evidence of off-site contamination risk is documented (Perozzi and Holliger 2008), it has been found that provided proper precautions are taken with respect to site preparation and maintenance, landfill quarries can be safe and stable . The success of after-use as a landfill depends in part on after-use monitoring and contingency-management policies, and in part on site geology, methods of extraction and rehabilitation previously employed, and the nature of the waste products being stored.

The third-largest municipal landfill in North America successfully operates within a former limestone quarry outside Montreal (Perozzi and Holliger 2008), while another large Canadian landfill is located in a former sand and gravel pit in Maple, Ontario (King et al. 1993). At both of these sites considerable structural engineering, maintenance, and monitoring were a necessary part of developing the landfill operation, but as a result safe and functional waste storage is provided. Furthermore, while pits and quarries are on the one hand useful tools for waste storage, on the other hand some waste products, such as those resulting from construction and demolition projects, may be seen as useful building blocks in the creation of landforms required for successful ecological rehabilitation. In California, the Bradley West Landfill is located within a former gravel pit and furthermore the landfill has been used to produce methane, which is collected and used by the municipality

Pits and quarries often interface between surface and groundwater, which may be seen as a valuable tool for managing water resources at a regional scale. For example, a quarry lake outside Milan, Italy was used as a water-pumping site in order to draw down the water table in parts of the city where subway tunnels were at risk of flooding due to a regional trend of rising groundwater (Beretta et al. 2004). Further control of regional water resources was demonstrated in Spain, where a series of gravel pits and check-dams were found to function efficiently at preventing flooding regionally, and enabling artificial groundwater recharge during periods of peak precipitation and flood-risk (Martin-Rosales et al. 2007). Additionally, the land-water interface provided at some extraction sites can provide ideal locations for the pumping of drinking water, or, as in Zadar county Croatia, treatment of wastewater (Dragicevic 2008). In Chicago, a Thornton Quarry was extracted for the primary purpose of constructing a water reservoir, which is now part of the City's water supply.

Former mineral extraction sites can provide wide open spaces and strong structural foundations conducive to a variety of large-scale construction projects. In Israel, quarries located in the vicinity of industrial developments often house new industrial manufacturing or processing plants once aggregate extraction has ceased (Milgrom 2008). Near London, England, a 100 hectare

Lafarge quarry became the site of the extensive Bluewater shopping mall complex, a 1.17 million-euro project that created 6,800 permanent jobs and is expected to stimulate the economy significantly (Lafarge 2009c). Similarly, a Lafarge quarry near Caracas, Venezuala was developed into an area featuring a school, subsidized housing, and landscaped parks sown with local vegetation and planted with 5,500 trees; this project was aimed at improving urban poverty in shantytowns that had formed outside of the city and had encroached upon the depleted quarry even before rehabilitation had begun.

In addition to space and stability, quarries often present aesthetically pleasing landscape features such as cliffs and water bodies; such features can improve the value of residential developments if they are retained, while providing habitat for diverse species, and ecosystem functions such as water filtering. In keeping with this approach, the Lafarge quarry in Shalersville, Ohio, was rehabilitated to a residential development with a strong emphasis on lakes that would collect runoff and protect the water quality of the Cuyahoga River, while simultaneously providing aesthetically pleasing landscape features and biodiversity (Lafarge 2009d).

Water bodies at extractions sites may also be utilized successfully in developing marina facilities; in Connecticut a marina was developed in a flooded brownstone quarry, and connected to the Connecticut River by constructing a canal through an isthmus separating the two systems (Baillie 1992). In San Fransisco, there are several residential and commercial developments around the Bay (e.g. The Brickyard Landing,) that were designed to benefit from the physical nature of former quarry sites.

In Ontario, residential subdivisions have developed that maintain some of character of the previous land-use in towns such as Galt and Dundas. The University of Toronto's Erindale College was constructed on the site of a former gravel pit, for which the OSSGA Bronze Plaque was awarded in 1980 (OSSGA 2009)

Less-conventional forms of "development" after-uses for rehabilitated extraction sites also exist. In Israel, very little land is available for development of any sort. One valuable after-use for depleted quarries is to convert them to "high-rise" cemeteries (Milgrom 2008). In England, the 2009 MPA Cooper-Heyman Cup was awarded to Lafarge for the creation of a 60 hectare

National Memorial Arboretum in commemoration of British soldiers fallen in combat since 1948 (Mineral Products Association 2009). While this site features built monuments and amenity structures for visitors, much of the area is a wooded parkland featuring 50,000 planted trees, and a mosaic of lakes, ponds, grasslands and wetlands.

In Shanghai, China, development is planned for a luxury hotel set in the base of a deep water-filled quarry; the hotel will be surrounded by water and high cliff faces, and will contain marina, restaurant, and large aquarium facilities (Greenroofs 2009). The hotel design includes extensive green-roofing, use of geothermal energy, and easy access to recreational sports such as rock climbing and bungee jumping.

A quarry in Kent, England, owned by the Brett Aggregates and situated adjacent to Ministry of Defence land was developed into a deep lake surrounded by wetlands and woodlands to be used in army training, a rehabilitation project that was granted a UEGP Sustainability award in 2005 (UEPG 2005).

Quarried landscapes can provide excellent field locations for filming television and movies, given the expansiveness, variety of landforms, and feasibility of environmental manipulations at such sites, with the often short distance to urban locations providing a further advantage. Such potential was realized with great success in the filming of much of Peter Jackson's "Lord of the Rings" trilogy at Dry Creek Quarry, in Wellington, New Zealand.

Finally, depleted pit and quarry sites have a number of properties that make them useful for education and scientific research. Many sites are used by schools and colleges for outdoor classroom exercises or simply fossil hunting ( eg  Quarry Park in Rochester US).  Sites can also serve as massive "laboratories" for a variety of scientific experiments in landscape design, applied ecology, agronomics, engineering, hydrology,  among other disciplines, with wet and dry portions of sites providing a wide range of environmental conditions..

## 6.0 CONCLUSIONS

While our scan of rehabilitation technologies (Chapter 9) suggested that a wide diversity of after-uses for extraction sites is possible, the highly successful initiatives reviewed here prove that the potential to meet diverse management goals can indeed be realized in practice, through creative, insightful, and comprehensive rehabilitation planning. Natural heritage, agricultural, recreational, and development goals appear to be met best when particular after-uses are chosen that work with, rather than against environmental features that emerge from the extraction process. Extraction sites are ecosystems that can to some extent be guided in their development to meet particular management goals, but which are also subject to influence by site history, local climate, and random events such as propagule immigration from surrounding ecosystems. While many such goals have value, only some can be pursued at aggregate extraction sites in a cost-efficient way. Of these, some conflict with one another in practice, while others are complementary. In the most successful rehabilitation projects investigated here, multiple complementary goals were set and achieved through a combination of intensive site engineering and directed natural processes.

Lakes, ponds, streams, and wetlands generated by extraction processes provide some of the most useful properties of extraction sites. At the landscape scale water retention and cycling through quarries can contribute invaluably to reduced flooding in surrounding regions. Since such water bodies often interface with aquifers, pits and quarries can be useful sites for groundwater recharge. Food webs form in flooded pits and quarries, beginning with aquatic microorganisms and quickly moving up to predators such as large fish and waterfowl, including species of high conservation priority. While extensive management would be needed to “remove” water bodies from sites where they formed as a by-product of extraction, only moderate effort is needed to format the number, shape, or size of water bodies: creation of islands, spits, and gently sloped or shelved littoral areas can greatly enhance the utility of the habitat from the perspective of wildlife.

Reedbeds and other wetlands that develop naturally or with assistance in shallow areas of such water bodies can increase biotic diversity, productivity, substrate stability, and water quality. Flat, wide-open areas of quarry floor that are dry at least some of the time can variably host communities of grasses, shrubs, trees and wildflowers typically hailing from ecosystems ranging from wet meadow to grassland, savanna, scrubland, woodland, or natural limestone pavement, depending on substrate and moisture conditions. Moderate efforts in terms of soil preparation, drainage control, and plant introductions can thus shift the balance of flora one way or another as desired, enabling realization of any or all of a relatively large number of ecosystem types at a given site.

Similarly, grains, vegetables, timber plantations, botanical gardens, pasture grasses, and turf grasses can generally be grown, though with some "crops" requiring considerably more site preparation or maintenance than others. Vegetated landforms ranging from rolling grassy hills to flat turfgrass-covered playing fields, woodland groves, forested cliff faces, and wildflower-covered scree slopes can be established through combinations of hydro-sowing, strategic planting, and spontaneous colonization. A variety of landforms and vegetation types attracts a diversity of animals to rehabilitated sites, from dragonflies, butterflies, and honey bees, to various birds, rodents, badgers, otters, rabbits, and deer. Diverse biotic communities can increase the goods and services obtained from the land by people, with insect pollinators benefiting agricultural crops, diverse fish populations increasing recreational fishing success, and diverse bird species increasing enjoyment gained from bird-watching. Similarly, swimming, scuba diving, and boating in quarry or gravel pit lakes are better appreciated when shores and shallows are well-vegetated and efficiently functioning in their capacity to filter water. Dry-land recreational activities such as hiking, camping, biking, and organized sports are more enjoyable when there is a diverse and healthy cover of living flora and fauna across the landscape.

Landforms resulting from extraction such as cliffs and steep slopes can provide aesthetic appeal, wildlife corridors, and marks of visual distinction in the landscape that improve the value of commercial and residential developments in such environments. Given the heterogeneity of extraction sites and the diversity and hardiness of species that can colonize them, locally rare but regionally important community types well-adapted to analogous environmental conditions in nature may be utilized in residential, recreational, or commercial endeavors, above and beyond their use in areas set aside for nature conservation. For example, diverse and visually attractive rock outcrop flora may be used heavily and intentionally in the establishment of gardens, lawns, boulevards and park areas, even if a site is to be converted to a housing development, school, or shopping area. Conversion of extraction sites to theatres, concert venues, and land-art exhibition sites should likewise consider the geology and ecology of extraction sites critically and imaginatively to maximize success.

Of the various geographical regions giving rise to the case studies investigated, rehabilitation efforts in the UK have been particularly exemplary. The reason for this seems to be tied to the “culture of sustainability” that has developed in UK industries with respect to interactions with the environment, at the demand of the public in a small country where demand for land is extreme and “recycling” of the landscape is a necessity. Marks of such a culture are the intense promotion and ready acknowledgement of high-quality rehabilitation work; forged partnerships among industries and land-trust agencies; and recognition of potential complementarity between human needs and nature conservation.

Some rehabilitation efforts in other regions, including Spain, China, and the United States have exhibited creative and comprehensive planning similar to that characterizing UK projects, but many other rehabilitation efforts have incorporated considerably fewer dimensions with respect to setting goals and targeting land-uses.

Future rehabilitation efforts in Ontario will likely be most successful if for each extraction site, the full range of possible land-uses is considered. Rehabilitation plans should be set based in part on the maximum diversity of complementary rehabilitation goals that can be achieved at a given site, considering the entire spectrum of natural heritage, cultural, recreational and developmental goals. At a higher level of management, long-term stability of individual rehabilitated sites may be more successfully achieved if spatial networks of sites dispersed throughout the wider region are considered at the same time. Under this approach sites would be rehabilitated to maximize contributions to regional-level goals, such as water management, biodiversity corridors, and human access to the widest range of services provided by rehabilitated extraction sites.

Appendix A

OSSGA’s About Aggregates Brochure #3, Rehabilitation of Pits and Quarries

ONTARIO STONE, SAND & GRAVEL ASSOCIATION

*Essential materials for building a strong Ontario*

# REHABILITATION OF PITS AND QUARRIES

*Aggregate extraction is an interim land use. Once aggregate is extracted from a pit or quarry, the site is rehabilitated into productive wildlife habitats, wetlands, golf courses, recreational parks, urban uses, conservation lands, forestry or agricultural lands.*

Dufferin Aggregates' Milton Quarry used landform simulation techniques to create escarpment cliff and talus slope environments as seen here. The quarry, located on the Niagara Escarpment, now features lakes, wetlands and islands. The new topography now supports aquatic, terrestrial and cliff habitats.

## WHAT IS REHABILITATION?

Rehabilitation of a pit or quarry involves the management of all of the property's natural resources during the aggregate extraction process.

Topsoil, including the seed sources that it contains, and overburden are managed carefully (i.e. stripped and placed separately in a manner that reflects the original profile) throughout the life of the operation to ensure that they can be used to progressively create a new landscape and land use for the pit or quarry.

Rehabilitation sequences are carefully planned during the preliminary licensing process, and become a legal requirement when the site is first licensed. As the aggregate extraction progresses through the site, the topsoil and overburden are sequentially replaced to ensure that the property is properly prepared for its future land use.

Rehabilitation activities commonly include wildlife habitat restoration and forestry management activities, proper soil enhancement to ensure agricultural productivity, landform creation to support recreational activities, and many other state of the art techniques designed to ensure the next land use for the property is productive and sensitive to local land use patterns.

*The former James Sabiston pit in the Oak Ridges Moraine is now a thriving horse farm in the town of Whitchurch-Stouffville. Between 1972 and 1983, approximately two million tonnes of sand and gravel was extracted from the site. Some extraction was below the water table in the eastern part of the site resulting in these ponds.*

## PROGRESSIVE REHABILITATION

Aggregate producers must perform **progressive rehabilitation** as they extract their sites. Progressive rehabilitation means rehabilitation done sequentially within a reasonable time after extraction of aggregate resources is complete.

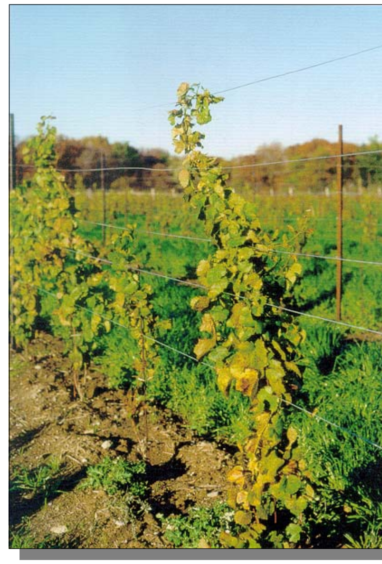
As one area of their pit or quarry is being extracted, rehabilitation must be completed in the areas where the aggregate reserves have been exhausted. Progressive rehabilitation is beneficial in many ways as it:

- Reduces the open areas within a pit or quarry
- Reduces soil erosion potential
- Reduces double-handling of soil materials

*Capital's Pit #2 in Puslinch Township near Cambridge, Ontario, is an excellent example of aggregate extraction as an interim land use. This pit was extracted and fully rehabilitated within a ten year time frame. It is currently used for hay production and is fenced for livestock.*

## EXAMPLES OF AFTER USES

*The former Preston Sand & Gravel pit near Kitchener was rehabilitated, in partnership with the Grand River Conservation Authority, to create warm and cool water ponds for fish habitat and wetland areas, and to provide flood storage functions. Currently there are osprey and eagles nesting here.*



*Vineland Quarries converted a 10-acre site into a productive vineyard with the assistance of the University of Guelph and Vailmont Vineyards.*

There are many good examples in Ontario of after uses. These include:

- *Agriculture*
- *Tender fruit production and grape vineyards*
- *Naturalization and wildlife habitat*
- *Wetlands, floodplain habitat development*
- *Golf courses*
- *Recreational parks and lakes, trails and conservation lands*
- *Forestry*
- *Urban uses*

Factors that are considered when selecting an appropriate after use include:

- *Surrounding land uses – present and future*
- *Surrounding ecological/natural heritage systems*
- *Stakeholder input (neighbours, municipalities, special interest groups, partners)*
- *Method of extraction (depth, proximity to water table)*
- *Available resources (topsoil, overburden, seed bank, transplanting opportunities)*
- *Geology of the deposit*

**There are more than 70 rehabilitated pits and quarries within the city of Toronto**

Smythe Park in Toronto is a rehabilitated pit. It received the Bronze Plaque Award from the APAO in 1977 (see About Aggregates #2).

# REHABILITATING PITS AND QUARRIES

These seedling at Lafarge's Uxbridge Pit on the Oak Ridges Moraine will grow to look similar to these trees which were planted in the 1970's at Lafarge's Blake Pit (inset), just down the road from the Uxbridge Pit.

Lafarge and the Ministry of Natural Resources are conducting research on reforestation techniques on this property. Reforestation is an after use that fits in well with the surrounding landscape and ecosystem.

J.C. Duff Ltd. and Armstrong Brothers Co. Ltd. extracted sand and gravel from this site in Brampton between 1949 and 1966. It was rehabilitated to an attractive lake and urban recreation area, called Norton Place Park, that also includes apartment buildings, condominiums and businesses.

**"I drive by this site every day and had no idea it was once a gravel pit"**
*- local politician*

**"Many sites are not visibly recognizable as former pits"**
*- tour attendee*

**"I think it's really amazing that pits can be turned into farmland."**
*- student*

Also available in the "About Aggregates" series:

1. Aggregates and the Law
2. Bronze Plaque Award Program
3. Rehabilitation of Pits and Quarries
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# CHAPTER 11
# SAROS PAPER 6: REHABILITATION
# CONCLUSIONS AND RECOMMENDATIONS

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The objective of the SAROS study was to gain a better understanding of aggregate resource management, with a focus on six key areas: demand, availability, economics, alternatives, recycling/reuse, supply, and rehabilitation. Specifically, this Report addressed *Rehabilitation* and had as its primary objective: to provide insight into the status of rehabilitation in Ontario. This was achieved through the assessment of a sample set of sites, a review of public expectations surrounding rehabilitation, and a global review of current science and technology and after uses of aggregate sites.

It was beyond the scope of this study to undertake a critical analysis of relevant policies and legislations related to the rehabilitation of pits and quarries in Ontario. However, it is important to note that the while the ARA does clearly stipulate that progressive and final rehabilitation shall be undertaken at each site, it does not specify any timing requirements (S. 48). Other supporting policies and legislations, such as the Greenbelt Act, are more prescriptive in nature and set out specific objectives related to the amount of progressive and final rehabilitation.

Based on the interviews conducted as part of this study, it is apparent that, with some notable exceptions, the aggregate industry is not meeting public expectations related to the amount or timing of rehabilitation. This is consistent with MNR's 2006 review of the ARA which concluded that "*a significant component of the aggregate industry is not making sufficient efforts to progressively rehabilitate their aggregate sites as evidenced by an inventory of licences conducted on the Oak Ridges Moraine and from discussions held with aggregate inspectors.*" Nonetheless, there was consensus amongst respondents that there are mechanisms that could be put in place to address this issue.

The assessment of the Task 1 sample sites found that for those sites where rehabilitation is being undertaken, the approaches are generally consistent with the requirements as set out by the site plans and the ARA. Nonetheless, the use of more traditional rehabilitation techniques (e.g., site levelling and homogeneity in micro-topography and the use of commercially available seed mixtures) has tended to limit the diversity and productivity of ecological outcomes. However, it is very important to note that many of these same site plans were developed at a time when end use targets tended to focus more on level, productive capacity such as farming or forestry. Depth to water table, site preparation and soil handling were key considerations in those works and end land uses, with a lesser emphasis on maximizing ecological benefits. Nonetheless, some examples of sites were found to be providing habitat and hosting associated species of plants and wildlife that are uncommon and/or under level of decline (e.g., sedge wren, upland sandpiper, bank swallow).

Based on the sample of surrendered licences inventoried, rehabilitation has been completed to provide for a wide diversity of land uses and, in most cases, the general public would not recognize the site as a former pit of quarry. Many examples are so well rehabilitated that they essentially fade into the landscape, within which they are integrated.

The global scan of technologies and after uses revealed a wide range of approaches to the rehabilitation of pits and quarries and to the scope of end uses. Similarly, this research demonstrated a range in the relationship of the aggregate sector with government and non-government organizations and also academia, and suggests that there are opportunities to develop more innovative partnerships in Ontario.

This report contains many recommendations for consideration, with most individual chapters containing detailed recommendations. These have been consolidated in an appendix to the Executive Summary. The following are a few comprehensive observations and recommendations emerging out of the 9 Tasks undertaken in fulfillment of the requirements of Paper 6: Rehabilitation:

1. Additional funding and support of the Aggregate Resources Program within the MNR would enable greater assistance and education for operators in their progressive and final rehabilitation efforts. Further, a rehabilitation specialist specific to the aggregates program could be a primary contact for Aggregate Resources Officers and operators, disseminate science and global research to the operators and ARO's, and make information on rehabilitation available to the public through newsletters, annual reports, awards, website, etc.

2. Existing policies and legislations, including the ARA, are generally well suited to prescribing broad-level approaches to the rehabilitation of pits and quarries in Ontario. However, the development of detailed best practices guidance documents, updated regularly, and associated forums that are suited to the needs of small to large scale producers will facilitate the implementation of key policies and legislation, and ultimately translate to higher quality and more timely rehabilitation.

3. In order to improve rehabilitation in terms of quantity, quality and timing, there should be investigation by the province of potential incentives for producers. Many examples were cited by public contacts that would provide ideas for consideration.

4. The absence of data related to the quantity and quality of rehabilitation being undertaken in Ontario in a readily useable format, opens the existing state of rehabilitation up to criticism. Improved documentation of surrendered licences and rehabilitation in Ontario will provide a better basis for evaluating trends over time, and for responding in a substantive manner to criticisms.

5. Public awareness and understanding of processes and policies related to aggregate extraction and rehabilitation is lacking. There is a need for increased education, outreach and dialogue between the industry, the public, provincial agencies and ENGO's.

6. The relationship between the aggregate industry and non-governmental organizations in Ontario has tended to be relatively non-collaborative. This contrasts with many of the case studies reviewed in the global scans. Internationally, there are examples of partnerships between industry, non-government and government organizations, and research institutions aimed at better balancing the demands for aggregate materials with other socio-economic and ecological considerations. This has translated to some outstanding examples at the planning and implementation stage of rehabilitated pits and quarries that successfully meet a broad range of local and regional objectives. There are many opportunities to expand the scope and breadth of industry-ENGO relationships in Ontario to achieve broader landscape level objectives. The industry and ENGO's are encouraged to continue their collaboration towards these and other goals.

7. Rehabilitated sites have not fully optimized the potential for contribution to broader provincial objectives for healthy communities. Improved collaborative decision-making between provincial and municipal governments that maximizes cumulative benefits associated with the rehabilitation of multiple sites will serve to better achieve landscape level gains.

8. Aggregate producers are largely adhering to current science recommendations and to the rehabilitation specifications set out in site plans. It appears that most innovations and substantial ongoing efforts are being accomplished by the larger and medium-sized producers.

9. There is a need to better integrate emerging science recommendations into the rehabilitation of pits and quarries, and to ensure that the research, in turn, responds to identified knowledge gaps. Encouraging innovation and flexibility in approaches to the rehabilitation of aggregate pits and quarries will foster advances in the understanding of ecosystem processes. Similarly, drawing not only from novel approaches within the province but also from other jurisdictions will continue to expand the knowledge base. The establishment of a core group of experts, (perhaps building on the outcome of the October 14, 2009 workshop) focused on fully integrating theoretical with applied research, is well positions to respond to knowledge gaps and will serve to better respond to the needs of both aggregate producers and Aggregate Resource Officers.

# CHAPTER 12

# SAROS PAPER 6: REHABILITATION

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