FUELLING DEBATE: A LOOK AT THE PROS AND CONS OF GREEN FUELS

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Some people look to the electric car, others to hydrogen, but in reality, we are likely to see several technologies converge to produce the fuel efficient engines of tomorrow.

Recently, the United Nations weather agency said that gases blamed for global warming have reached record levels in the atmosphere. Concentrations of CO_2 and nitrous oxide (N_2O) touched new highs in 2008, and methane had its largest annual increase in a decade.

There are many technologies that will be used to keep our equipment working economically in the future. Rather than a single predominant one, such as gasoline or diesel engines (CO_2 per litre of gasoline burned = 2.34kg/L; CO_2 per litre of diesel burned = 2.68kg/L), we will more likely use a combination. Some people look to the electric car, others to hydrogen, but in reality, we will probably see several technologies converge to produce the fuel efficient engines of tomorrow.

Let's look at the different fuels we might use in the future and their pro and cons.

Battery

Electric cars are far from new. They were common between the 1830s and 1930s and re-emerged in the 1960s and 1970s. The first modern electric car was produced in 1996 by General Motors. The source of power for the electric car usually comes from rechargeable batteries (pure electric cars), fuel cells (fuel cell cars), or a combination of gasoline and rechargeable batteries (hybrid cars).

These technologies are used today on walking greens mowers and riding mowers available in hybrid or battery drive, providing power, economy and low environmental impact. Unfortunately, pure electric equipment is impractical because the batteries need to be recharged, sometimes after cutting only a few greens or fairways, or even less in extreme hot or cold weather.

Recharging batteries can take as long as three hours for a full charge. To get more power, more batteries would be needed, increasing both weight and footprint on

greens and fairways. Furthermore, batteries have to be disposed off, which creates another environmental concern.

Biodiesel

Biodiesel is a renewable fuel derived from vegetable oils, animal fat and cooking oils. These oils and fat are made into methyl or ethyl esters. One of the big advantages to using biodiesel shows up in the engine. Analysis revealed that the improved lubrication qualities of biodiesel may increase some major engine parts longevity by as much as 100 percent and increased longevity reduces maintenance costs.

Disadvantages are that biodiesel has slightly less energy than regular diesel, so if we were to use biodiesel in a vehicle, the engine would either have less power or use more fuel to deliver equal power. Biodiesel causes fuel-system problems in cars, especially at low temperatures. It oxidizes faster due to its chemical makeup so storage of the fuel is more difficult.

The biggest disadvantage of biodiesel is that pure biodiesel begins to freeze or solidify at low temperatures. Nitrous oxide can increase up to 6 percent and refining the renewable source of biodiesel causes greenhouse gases. To combat these problems, the Austrian company BDI (Bio Diesel International) is currently working on using algae as raw material for the production of biodiesel. The algae are grown either in fresh or salt water, need no agrarian land, and are fed by exhaust emissions stemming from caloric power stations which leads to a further reduction of the gases responsible for climate change. Algae produce 80 times more usable biomass than rape seed per hectare thus potentially eliminating the use of valuable agricultural product needed to feed the world.

Ethanol

Ethanol is a clear liquid that can be made from natural products and is diluted with gasoline to provide a cleaner, more natural fuel source. About 30 percent of all gasoline consumed is blended with ethanol, usually a combination of 10 percent ethanol and 90 percent gasoline. Ethanol is produced from crops such as corn, grain sorghum, sugar cane, wheat and biomass.

Ethanol has both economical and environmental shortfalls. Many acres of cropland are needed to produce ethanol, which makes it more expensive than gasoline. It contains one third less energy than gas, which means mileage is 30 to 40 percent lower. Massive ethanol production could cause a shortage of corn available for food and destroy habitat. It also increases smog in urban areas. The cost to produce and refine one litre of ethanol was $2.19 in 2008 and is subsidized heavily by government.

Methanol

Also known as wood alcohol, methanol is an alternative fuel that can be produced from any carbon-based source like natural gas, coal, wood wastes and seaweed. Using methanol as an alternative fuel source is good because it produces lower emissions, yields higher performance, and has

a lower risk of flammability than gasoline. Because the use of methanol creates better performance and acceleration, it is used as the fuel for Indy race cars, monster trucks and model vehicles.

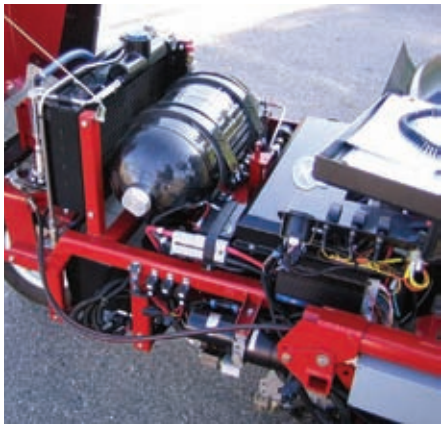
Methanol is more corrosive than gasoline so parts that come into contact with methanol must be able to withstand its corrosive ability. Also, because the air to fuel mixture is richer than gasoline, a given volume of gasoline will take you about 70 percent farther than the same sized tank of methanol. Methanol is a very toxic substance and can be harmful if swallowed, absorbed through the skin or inhaled. Ingestion of just 1 to 4 ounces can cause injury to the nervous system, blindness or even death.

Hybrids

A hybrid electric vehicle (HEV) uses an electric motor and a gasoline engine. The engine charges the battery and extends the range and provides extra power. The fuel tank is the energy storage site for the gasoline engine. The generator produces electric power. The batteries are the energy storage devices for the motor. The motor can put energy into the batteries as well as take energy away from them. The engine has enough power to keep the equipment moving, and the extra electric motor and battery provide the additional power needed to go up steep hills. The batteries in today's hybrids require nickel, which is costly, and big battery packs and other components can add $2,000 or more to the cost compared to conventional models. The large battery packs degrade performance and increase the footprint of the associated turf equipment.

Natural Gas

Natural gas is basically methane (CH_4). Its largest advantage is its chemical composition. Because methane only has



Adjacent Top. The on-board hydrogen 26L Dynatek fuel cylinder capable of containing 0.63 kg of hydrogen at 5000 psi. Adjacent. Toro's mid-duty fuel cell hybrid combining a Maxwell ultracapacitor bank and Hydrophonics fuel cell.

one carbon in its composition, it produces very low carbon emissions. The second major advantage of natural gas is convenience. The gas is pumped directly on the consumer's property. Because of the abundance of natural gas, it is cheaper to burn than oil.

Fuel Cells

These devices generate electricity by converting hydrogen and oxygen into water. Here is what happens in a fuel cell. When hydrogen gas pumped from the fuel tanks arrives at the anode, which is made of platinum, the platinum catalyzes a reaction that ionizes the gas. Ionization breaks the hydrogen atom down into its positive ions (hydrogen protons) and negative ions (electrons).

Both types of ions are naturally drawn to the cathode situated on the other side of the membrane, but only the protons can pass through the membrane (hence the name "proton-exchange"). The electrons are forced to go around the proton exchange membrane, and along the way they are shunted through a circuit, generating the electricity that runs the car's systems.

Using the two different routes, the hydrogen protons and the electrons quickly reach the cathode. While hydrogen is fed to the anode, oxygen is fed to the cathode, where a catalyst creates oxygen ions. The arriving hydrogen protons and electrons bond with these oxygen ions, creating the two "waste products" of the reaction – water vapour and heat. Some of the water vapour gets recycled for use in humidification, and the rest drips out of the tailpipe as "exhaust."

This cycle proceeds continuously as long as the car is powered up and in motion; when it's

idling, output from the fuel cell is shut off to conserve fuel, and the ultracapacitor takes over to power other components. Ultracapacitors (sometimes called double-layer capacitors or supercapacitors) store energy electrostatically by polarising an electrolytic solution. Unlike batteries, no chemical reaction takes place when energy is being stored or discharged and so ultracapacitors can go through hundreds of thousands (or even millions) of charging cycles with no degradation.

Ultracaps are highly efficient, so little energy is lost during the charging and discharging process (typically <1 percent). As they do not depend on a chemical reaction to store energy, ultracapacitors can operate in a very wide temperature range effectively – typically from -40º to +70ºC.

When hydrogen is used in fuel cells, there are zero emissions. Toro and the New York State Energy and Research Development Authority (NYSERDA) joined forces to assess the potential of fuel cell utility vehicles at Niagara Falls State Park. NYSERDA had selected Toro to receive grant funding to develop the hydrogen powered vehicles. Toro converted two mid-size utility vehicles and one heavy duty utility vehicle using a fuel cell in a series-hybrid configuration. Without the fuel cell, the batteries would only provide about 20 to 30 minutes of run time. Since the fuel cell keeps the batteries charged, the batteries can provide 15 to 20 kW (20 to 27 hp) of peak power when needed. To date, these utility vehicles have operated fairly reliably and met or exceeded performance expectations.

Hydrogen

Hydrogen is a colourless, odourless gas that accounts for 75 percent of the entire universe's mass. Hydrogen is found on Earth only in combination with other elements such as oxygen, carbon and nitrogen. To use hydrogen, it must be separated from these other elements. The most inspiring and exciting use for this element would be for use as a fuel. Scientists have been exploring this for many years and now it is becoming more of a possibility as prototype hydrogen equipment and motors are being tested.

The production of hydrogen is very cheap and easy. Hydrogen is actually a by-product in the steam reforming of natural gas. Since natural gas already has a variety of uses in our society, this would be a very cost efficient way to produce pure hydrogen. Although the change will be tough, some of the benefits will be great.

For example, it is much more environmentally friendly to burn hydrogen than to burn gasoline. Another advantage to switching to hydrogen would be the availability of the resource. One last major advantage is the fact that it would be cheaper to refine than gasoline and thus would be cheaper for the consumer. Golf courses could have their own stations to produce and store hydrogen. The only tailpipe emission is water.

Prototype hydrogen equipment and motors are currently being tested. Hydrogen is readily available and more environmentally friendly to burn than gas. On the flip side, it's highly explosive and both storage and distribution systems still need work.

The Toro riding greens mower prototype utilizes a 7 kW hydrogenics PEM fuel cell and a bank of ultra-capacitors in a 48Vdc series-hybrid configuration. Onboard hydrogen is carried in a 26L Dynatek composite compressed gas fuel cylinder capable of containing 0.63 kg of hydrogen at 5,000 psi (350 bar). Field trials have demonstrated it capable of quietly and effectively mowing an entire 18-hole greens route without refuelling.

Other manufacturers of grounds equipment are also exploring fuel cells. Hydrogenics Corporation, a designer and manufacturer of fuel cell technology, announced in Toronto (June 2009) that it has sold six of its 10-kilowatt fuel cell power modules to Deere & Co. for integration and evaluation in off-road vehicle applications including grounds equipment and utility vehicles.

Pound for pound, hydrogen fuel has more inherent energy than gasoline, which could mean higher mileage. One of the main disadvantages is the explosive property of hydrogen. This means that special precautions will have to be taken for pumping and storing. There's no distribution system or standardized method of storage, which is crucial since hydrogen fuel is a gas that must be kept under high pressure.

Significant work still remains to make this a reality. Lots of data must be collected to ascertain the proper power specifications for the fuel cell-hybrid system. Carrying sufficient onboard fuel

is challenging, especially utilizing the large, cylindrical compressed gas tanks. Many of the components are prohibitively expensive, and economies-of-scale must be realized on several fronts to reduce the cost.

Finally, it is unclear how affordable hydrogen fuel systems will work, particularly in applications where the entire fleet consumption may be less than 10-20 kg/day. One solution could be "Hydrogenics On Site Generation" which offers a full line of HySTAT hydrogen station and turnkey hydrogen generating solutions for a wide range of hydrogen generating and refuelling options. Despite obstacles, customer satisfaction and demonstrated technical viability offer hope that some day hydrogen fuel cells might be a common sight on your local golf course. Even though there are some large disadvantages attached to the switch to hydrogen, it will be very beneficial in the long run and will finally eliminate damage to our environment. ♦

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IN-HOUSE, ARCHITECT-BID-CONTRACTOR, DESIGN-BUILD, OWNER'S REPRESENTATIVE. WHAT WORKS BEST FOR BUILDING YOUR SPORTS FIELD?

STMA ADVISORY BULLETIN 3, WWW.STMA.ORG

As a sports turf manager, you have the knowledge to advise the owner. What will be your recommendation?

Your organization has decided to build a new sports field and has determined which type of field is needed. Whether it is a single synthetic field, or a natural grass field, or a multi-use sports complex with both field types, one of your next steps is to determine the best method to get your project built.

As the sports turf manager, you have the knowledge to advise the owner. What will your recommendation be?

- Should your organization complete the project in-house?
- Hire a design professional, and when the plans are completed, bid it and subsequently hire a contractor?
- Or, is your project better suited to hiring one firm to design and build the project?
- Do you need to hire an owner's representative?

All options can provide your owner with a quality outcome, but each has unique considerations. There are also many variations on these models with some approaches using elements from several models. This technical bulletin will outline the advantages and disadvantages of these four conventional models.

Key Considerations

Generally, three major factors can influence the decision about which type of professional service you select:

1. Complexity of the project.

The complexity of your project can be a major decision-making factor for selecting in-house or another model for your project.

Consider the answers to these questions:

- Do you need any site use and utility studies completed? Environmental impact or analysis studies? Marketing and economic feasibility studies? Special cost or energy analysis?
- Are there zoning and planning approvals necessary? Will you need help with preparing materials for public referenda or any special drawings, models and presentations?
- Do you need help with developing financing opportunities?
- Are there any community concerns?
- Will your project be challenged by any climatic impacts? Unusual topography? Geotechnical characteristics? Ecological

features? Water issues or drainage accessibility?

2. Time you have to complete the project
The project's timeline can be another factor that influences which project process you pursue. All projects must have a realistic timeline that allows for appropriate approvals and decision making. Answer these questions to help direct you:
• Do you have adequate time to complete the project in-house while managing other responsibilities?
• Do you have time to select the architectural/design firm, have the design completed and subsequently hire a contractor?
• Do you need to fast track a project, overlapping design and construction phases?
• Do you need the time efficiencies a consultant may provide by effective coordination?

3. In-house expertise/resources available
Another major factor in considering the right delivery model is the availability and knowledge base of staff assigned to your project.
• Does your staff have the appropriate design, construction and project management experience? Easy access to equipment and materials?
• Do you have an in-house representative, such as a CSFM or professional sports turf manager, who can monitor the project's progress? Or, are you willing to hire one?
• How involved in the process does the owner wish to be?

In-House

For organizations that are renovating or building a new field or complex, handling it in-house is an ideal solution if time and resources are available. Many organizations have architects, purchasing departments and construction expertise on staff for the sports turf manager to utilize. However, some sports turf managers are unable to place on-hold the other duties of their jobs to undertake a project. It is challenging to design, manage, build a field, and continue with daily responsibilities.

Advantages of in-house
• Provides total control of the project.
• Well suited to urgent projects and less definitively scoped projects.
• Allows for quicker and more nimble decision-making.
• Permits fast mobilization of resources.
• Streamlines the budgeting process.
• Creates a team with a single sense of purpose.
• Protects the owner's investment because the owner is in charge.

Disadvantages of in-house
• Not well suited to large, complex projects.
• Must be able to prioritize the project within the organization's structure.
• Must have design and construction management experience on staff.
• Must have construction labour on staff with access to the necessary equipment.

Architectural/Design Firms

Typical services
Architectural/design firms offer a wide range of services. The owner first contracts for the design of the project. The design professional:
• Determines and oversees any site planning and evaluation services.
• Prepares plans and specifications.
• Usually assists in the bidding stage.
• May provide oversight of the project during the construction phase.
• May provide facility administration services following construction.

The design of the project is complete before the contractor is selected. The owner contracts separately with the contractor and retains the responsibility for overall project management.

Contract management function
In an architect/designer-bid-contractor model, the architect/designer may have a key role in assisting the owner with the hiring of the contractor and in managing the construction project. The architect/designer may:
• Evaluate the work for compliance with the drawings and specifications.
• Approve shop drawings, materials and project samples.
• Review the results of material tests and inspections.
• Approve the contractor's requests for payment.
• Handle requests for design changes during construction.

Basic Definitions

For Professionals Who May be Involved in Your Project

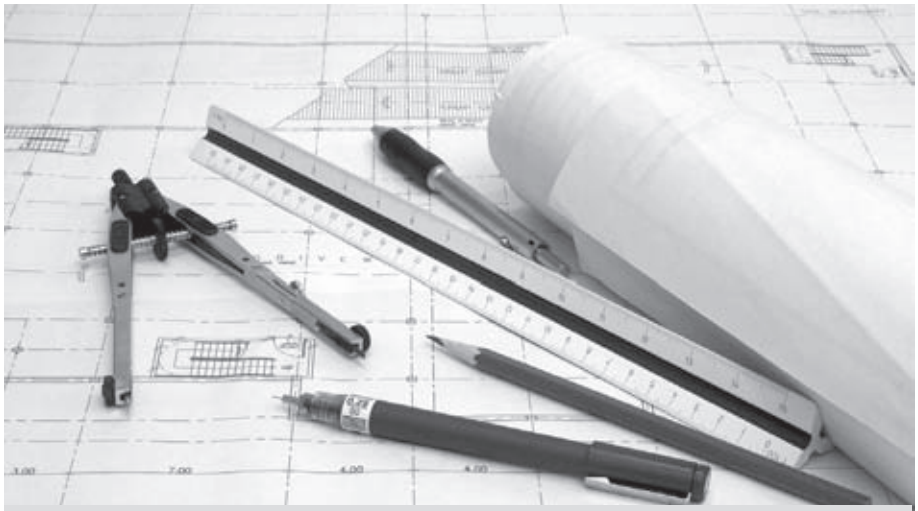
Architect. One who has completed a course of study in building and design, served an internship, and is licensed as an architect. The architect typically produces a set of plans and specifications on which the construction contract is based and is a member of the project team.

Certified Sports Field Manager (CSFM). The professional designation for a sports turf manager who has met the education and experience requirements of the Sports Turf Managers Association's (US) certification program and successfully passes the rigorous four-hour exam. Once certified, a combination of continuing education and industry service is required.

Construction Manager. May be involved in overseeing scheduling, cost control, construction, bidding, or the entire project. A construction manager is most useful on a large, complex project which requires a good deal of oversight and coordination.

Design Professional. Generally refers to architects, engineers, landscape architects and others whose services are "professional" activities requiring licensing or registration by the province or territory, or otherwise require the knowledge and application of design principles appropriate to the problem at hand.

Landscape Architect. A licensed design professional who plans, designs, manages, preserves and rehabilitates land. He/she provides design services for urban design, parks and recreation, environmental restoration, golf courses, etc.



Basic Definitions Continued...

Owner's Representative. Typically educated as a planner, architect, certified cost analyst or construction manager, he/she is responsible for coordinating all aspects of the project including master planning, design, preconstruction and construction administration. This person essentially takes the project from conception through completion with the express purpose of protecting the owner's financial interest. On smaller projects, this consultant may actually complete all phases him/herself.

Professional Engineer. Has fulfilled the education and experience requirements and passed the exams that permit him/her to offer engineering services. PEs take legal responsibility for their engineering designs and are bound by a code of ethics to protect the public health and safety. They have the authority to sign and seal or "stamp" engineering documents (drawings and calculations) for a design or a structure, thus taking legal responsibility for it.

Request for Proposal (RFP). A document that a company or organization sends to vendors to elicit a bid for products or services. An organization typically issues an RFP in order to assess competing bids. The RFP language should convey the full scope of the work desired and must produce responses complete enough for the issuing organization to make distinctions between competing vendors and determine which vendor is the right fit for the project. When used for a construction bid, the response to the RFP provides to the client a recommendation from the contractor on the best method of construction. Each project and site is different and each RFP should also be unique. Usually requires a representative, staff member or hired consultant who is knowledgeable in the scope of work covered by the RFP to assess the responses.

Request for Qualifications (RFQ). Usually a more basic request, asking for much of the information that would typically appear on the CCDC (Canadian Construction Documents Committee) 11 Contractor's Qualification Statement with some additional information. It is often the first stage of a two-stage procurement process that results in identifying companies that are qualified to do the work by their experience, financial strength and organizational resources. In such cases, only these pre-qualified companies are permitted to respond with pricing proposals. The process narrows the field allowing the client to only review bids and evaluate bids from companies that are determined to be qualified to perform the work. Organizations that are not required to take the lowest bid may use a more detailed RFQ process and do not subsequently develop an RFP. Usually requires a representative, staff member or hired consultant who is knowledgeable in RFQs to assess and validate the qualifications.

• Administer the completion, startup and close out process of the project.

Advantages of architect/designer-bid-contractor

• Minimizes risk through the owner's control of the design and construction phases.
• Offers checks and balances between the construction participants.
• Provides the owner with significant opportunity for input into the process.
• Is a well-understood and widely used model.
• Brings together a wide range of resources to solve complex problems.

Learn more! This topic will be addressed at OTS 2010. For details, visit www.ots.open.uoguelph.ca.

Disadvantages of architect/designer-bid-contractor

• Can be a lengthy process.
• Requires significant front-end economic commitment (since design is completed prior to bidding the construction phase, the bids could exceed owner's budget).
• Requires in-house expertise to coordinate and arbitrate between separate design and construction contracts (or must be willing to hire an independent representative).
• May place owner in an arbitrator position between design and construction.
• May require more change orders and ensuing costs as the project is constructed.
• May still require hiring an owner's representative to review plans and make recommendations to help reduce change orders and other potential expenses.

Design-Build

A design-build firm has full accountability for design, engineering and construction – taking the project from concept to completion. Consider the following when deciding if this "single source" service is right for your project:

Advantages of design-build

• Provides a single point of responsibility for design, construction, cost, quality and schedule adherence.
• Takes the owner out of the middle of

disputes between architect/designer and contractors.
• Allows for earlier knowledge of costs because the same team simultaneously estimates construction costs.
• May provide for faster completion due to the elimination of bidding periods and the overlap of design and construction.

Disadvantages of design-build
• May require specialized in-house staff or a consultant to develop the RFP or RFQ, oversee the project, and maintain quality control. It can be complex to write a comprehensive RFP for design and construction.
• May not be allowed by your owner. Some government entities may require the traditional architect-bid-construction process.
• May not be able to purchase liability coverage. Some liability insurance/payment bond carriers may not be familiar with design-build and adequate coverage may not be available.
• With the same firm designing and building the project, there may not be an independent, third party providing the necessary "checks and balances" to protect the owner.

Owner's Representative

This model employs a consultant, such as a CSFM, who ensures that plans are prepared correctly and construction is sequenced properly and executed as intended. For larger projects, this person may be hired in conjunction with a traditional architect-bid-construction service or to monitor a design-build project. For smaller projects, this person may fulfill all roles.

Advantages of an owner's representative
• Removes owner from conflict resolution between the architect/designer and contractor.
• Protects the owner's interests because sole allegiance is to the owner.
• More efficient coordination may result in less change orders, thus reducing costs.
• Highly knowledgeable consultant can save time and money.
• Well suited to large, complex projects or small projects where there is limited in-house expertise.

Disadvantages of owner's representative
• Adds another tier of decision-making.
• Contributes to the overall expenses of the project.

Summary

These are just a few considerations that may help you to determine the appropriate process to build your sports fields. Many options and variations exist. It is recommended that you further investigate these options with the Royal Architectural Institute of Canada (www.raic.org) and the Canadian Design-Build Institute (www.cdi.org). Other relevant links include the Canadian Construction Association (www.cca-acc.com), the Canadian Society of Landscape Architects (www.csla.ca) and the Canadian Council of Professional Engineers whose website is www.engineerscanada.ca. ♦

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Why Classify?

WITH RESPECT TO SPORTS FIELDS

R.W. Sheard, Editor-in-Chief, Athletic Field Construction Manual

Classification defined: "To arrange or group in classes according to some system or principle."

Classified advertising in the newspaper is an example with which everyone is familiar where items for sale, job opportunities, etc., are listed in alphabetical order. Libraries use a classification system to allow librarians to find a specific book among the millions of holdings on the shelves. For example, the Library of Congress Classification System identifies the *Athletic Field Construction Manual* as GV413.A84 2008. In fact, Open Text, a very successful Canadian computer company in Waterloo, Ontario began by computerizing the classification system for university libraries.

In botany, a classification system was developed by a Swedish botanist, Carolus Linnaeus, to arrange the names of all plant species into a logical classification system. Thus, when the name "Gramineae" is seen, one immediately knows the author is referring to some grass plant. When the additional words "Poa annua" are added, the grass plant becomes a specific organism. It is so specific that no other grass plant can have the same characteristics. It is also known by the common name, annual bluegrass. Common names, however, may change from region to region. In Ontario, everyone knows what annual bluegrass is. But in other regions it may be called "sweet grass." If the scientific name "Poa annua" is used, there is no confusion about what plant is being discussed.

In the early 20th century, Russian soil scientists used a similar concept to developing a system for classifying soils. Based on surface geology, texture and observable features of the soil profile (cross section to a depth of one to two metres), they separated soils into groups beginning with the basic unit, the soil series. There are over 400 different soil series mapped in Ontario. When a user sees that soil series name on a map or report, it immediately brings to mind certain information about the soil.

For example, a soil in Ontario mapped as the Guelph loam series informs the user of the map or report that the soil is located on the upper slopes of a slightly rolling topography; that the soil has developed on glacial till and contains a few stones; that the soil is well drained; and that it has a loam texture which indicates it has approximately one third each of sand, silt and clay. A knowledge of the underlying geology of the area would also infer that the soil has a pH above 7.0. Thus by using a classification system, a great deal of information can be conveyed by just two words – Guelph loam.

The Sports Turf Association developed a classification system for athletic fields when they prepared the *Athletic Field Construction Manual*. In the past, organizations such as municipal parks departments have developed in-house classification systems for their athletic fields based primarily on the sport for which they are used. For example, one municipality chose to classify its fields according to the sport for which it was to be used and the availability of irrigation. The editorial group for the STA manual, however, chose the physical requirements of the root zone, independent of the sport to be played on the field.

The basic unit of classification of fields in the STA system (Figure 1), comparable to the soil series in the soils system or the genus and species in the plant system, is the materials used in the construction of the root zone on which the turf will grow. This separation is based primarily on the amount of silt and clay which is permitted in the root zone and consists of five categories.

A Category 1 field is essentially a field constructed using USGA specifications which only allow 8% silt plus clay in the root zone mix. The remaining 92% of the total is sand which must meet certain