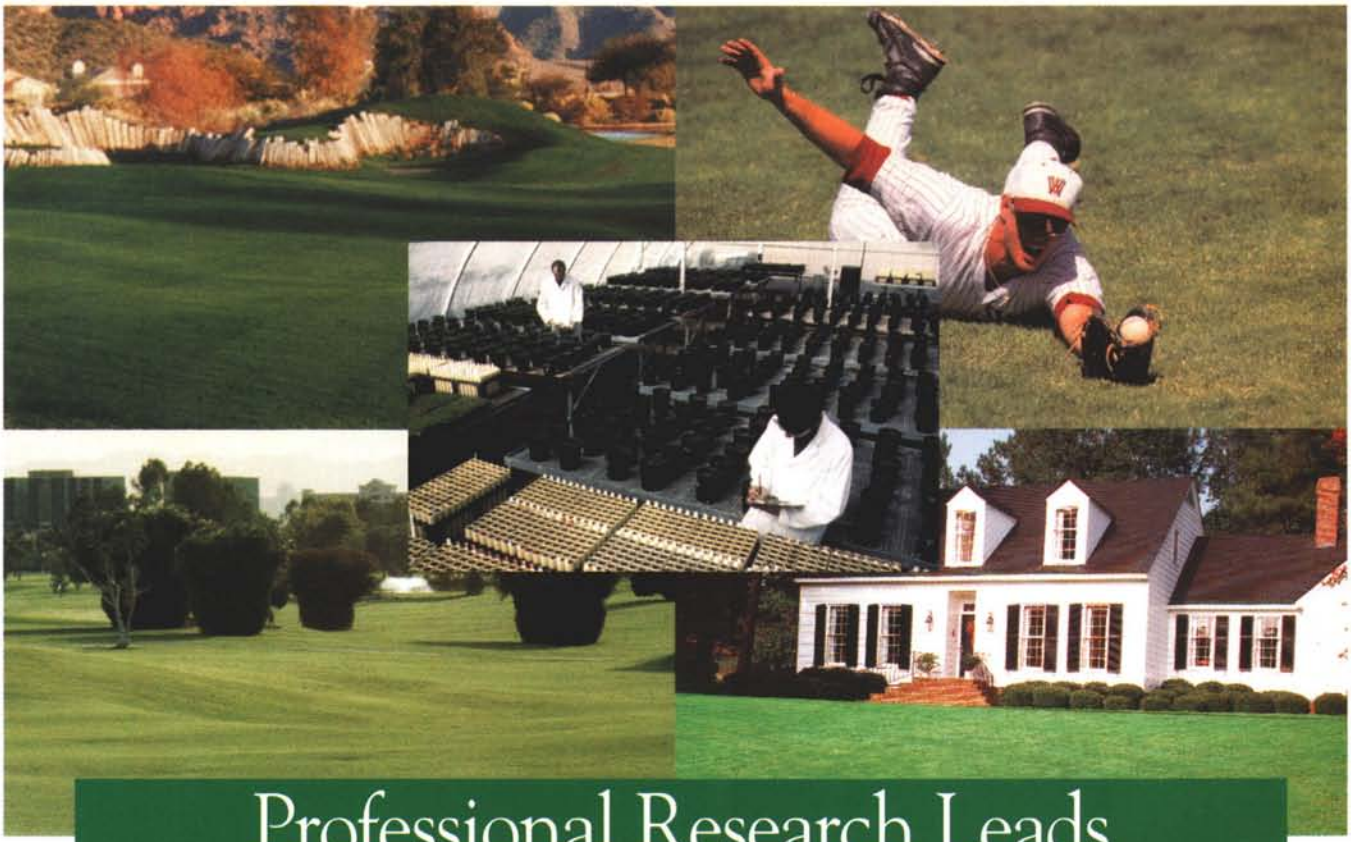

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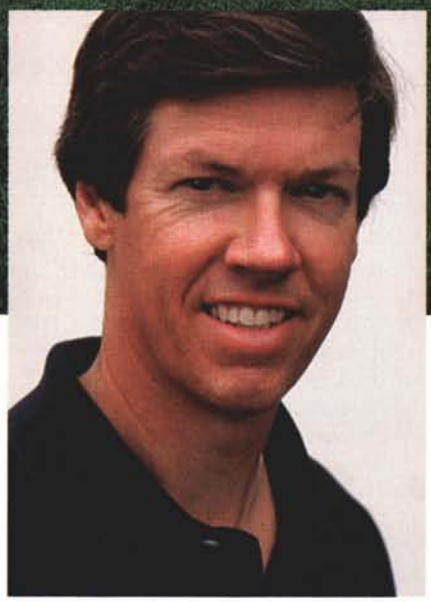

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Principles of Water Movement

Sportsturf drainage systems exist in many forms and shapes, but all share one common trait. While some water can be evacuated by surface runoff, most must percolate through the rootzone to reach some form of underground drainage pipe system.

How fast and effectively this percolation can occur, and the amount of water which will remain available for the turf determines the drainage system's overall performance. All of this is dependent on the interaction between soil particles and water molecules.

Up, down, all around

Water movement in soil can be compared to that of water through a sponge. When a dry sponge comes into contact with water, we see a wet front moving. This front can move downwards, but it will also move sideways, or even up.

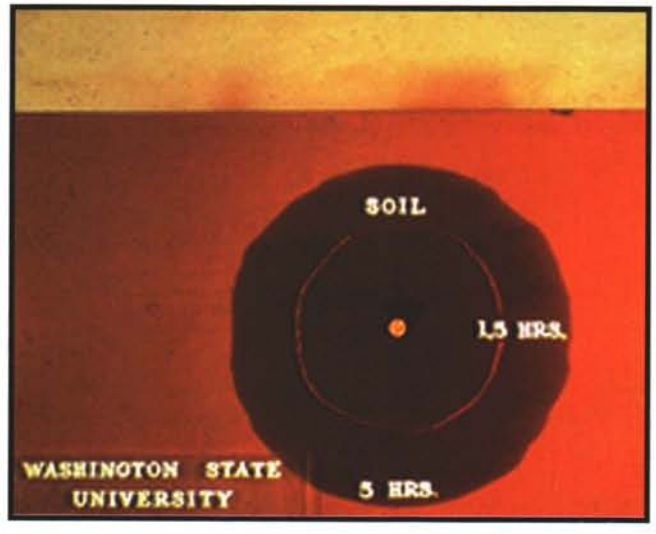
If a sponge is dunked into water and pulled back out, some water will flow out, but a certain amount will be held by the sponge. The forces holding water in the sponge are the same that cause the wet front to move through the dry sponge: capillarity and adsorption.

Water travels in soils exactly the same way. When water moves through a soil profile, water molecules attach themselves to individual soil particles by adsorption. This describes the attraction between dry surfaces and water molecules, and it's the same phenomena that explains why rain drops cling to a glass surface.

Once water molecules wet a particle, they seek another dry surface on which to cling. This movement from particle to particle is ensured by capillary forces, which bind water molecules together.

As the water front moves ahead, it pulls more water along with it. This is why we say that water is under negative pressure. The water doesn't push its way through the maze of pore spaces in the soil profile; it's pulled in by the combined adsorptive and capillary forces.

These forces cause the water front to move, but they also hold the water mass inside the soil. This attraction causes water molecules to move any which way there is a soil particle, independently of gravity.



Capillary and adsorptive forces combine to pull water through a soil profile in movements independent of gravity. *Courtesy: Lanco*

As water moves through the soil, the pores between soil particles gradually fill. Some water will freely escape the soil profile, having found its way through the bigger pores (≥0.06 mm in diameter).

As more water enters the system, all the pores become filled. Additional water has nowhere to go, so it starts to pour out of the soil profile. This is the actual drainage.

When the water supply is cut off, the larger pores empty out and drainage stops. Water caught in the smaller pores is held back by capillary forces, and it can be used by the turfgrass root system.

Compaction and water movement

In sports fields of every type of soil profile, the rootzone layer presents a certain pore structure. This unique combination of small, medium, and large pores determines the field's initial drainage capability.

The presence and arrangement of larger pores determines the soil's ability to drain freely. A soil composed of mainly fine particles will have few large pores. Water will be held captive, and poor drainage will result. On the other hand, a soil composed exclusively of large, coarse particles will drain freely, but will be incapable of retaining water necessary for plant growth.

Play and regular maintenance practices apply incessant pressure to the surface, which results in localized compaction. Compaction patterns are specific to each sport, but they're similar to the surface's wear patterns.

Pressure that's applied over and over will gradually pack soil particles together. This decreases the number of larger draining pores, and consequently decreases drainage performance.

Modern sports field design and construction increasingly integrates manufactured, compaction-resistant soil mixes. Combining medium- to fine-grade sands with organic matter and other materials, these soil mixes can withstand compaction while ensuring water retention compatible with turfgrass growth.

In a fine soil overlying a coarser, free-draining layer, water is held in, resulting in a perched water table. *Courtesy: Lanco*

Water retention and perched water table

Up to this point, the principles of water movement in homogenous soils are fairly easy to understand and visualize. Things get a little more complicated when we start laying one soil type over another, as is common in many sports field constructions.

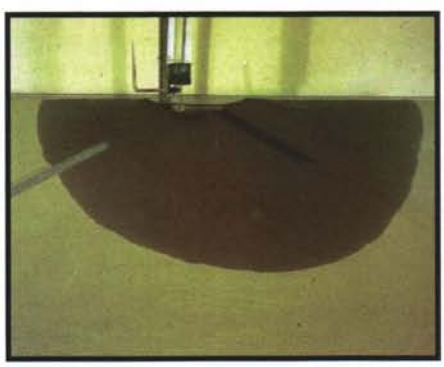
Let's get back to our sponge. After free-flowing water has stopped pouring out of the larger pores, you can pick up the sponge and it holds water. Put it down on a bed of gravel, coarse sand, or another material, and the water will remain in the sponge. Contact with a free-draining material will not induce water to flow out of the sponge.

The same is true with soils. Negative forces applied by the combination of adsorption and capillarity pull at water molecules and hold them captive. As particle and pore size decrease, these combined forces strengthen. If more water is added, it spreads through the profile and accumulates to the point of saturation.

If the soil profile overlies another which is coarser, water will accumulate in the finer soil until the weight of the water cannot be contained by the retentive forces and it starts flowing. This is called a perched water table.

This very common phenomenon is widely misunderstood. It's natural to assume that by placing a free-draining layer below a heavy soil, drainage will be induced from one layer to the other.

In fact, the exact opposite occurs. The greater the difference in particle size distribution between the two soils (granular discontinuity), the



When water is allowed to flow freely into coarse material, it moves unimpeded. When it must cross from a fine material into a coarser one, it is held by negative forces.
Courtesy: Lanco

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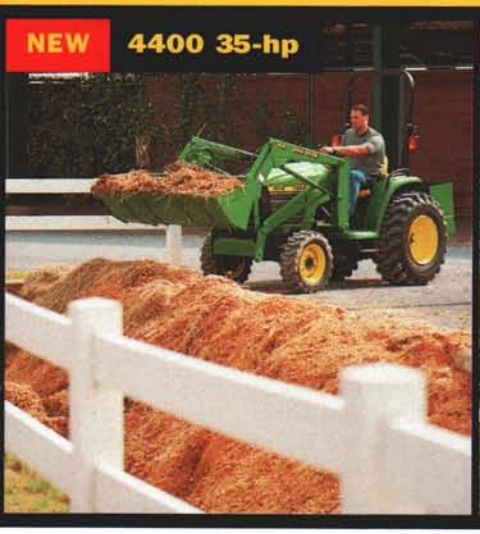

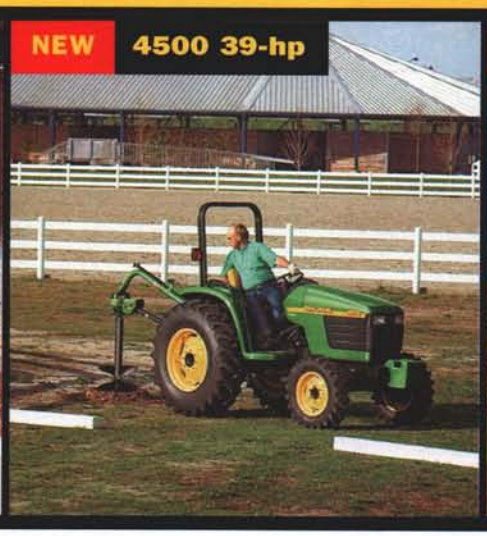

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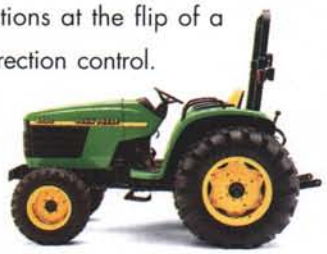

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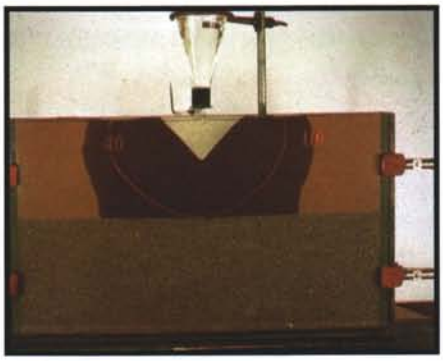
harder it is for water to cross over from one to the other.

This phenomenon will also occur when water tries to flow through a coarse material imbedded in a fine soil. The retentive forces keep water molecules captive in the fine soil, and perfectly dry coarse spots can be found in moist or wet soils. This can cause problems for drainage systems when water is supposed to flow from a fine soil into gravel or other material surrounding drainage pipe.

Water and soil stratification

Layers of fine material in an otherwise well-draining soil can also have very disruptive effects on water movement. Water will have no difficulty crossing from coarse to fine material, but water movement is much slower in the fine soil.



A fine soil layer can act as a barrier for water movement. *Courtesy: Lanco*

Such a barrier affects the whole potential of a drainage system. Once the fine material is saturated and water flows through into the coarser soil, its percolation rate has been reduced to that of the finer layer.

This common situation may seem inconsequential, but it can greatly affect a field's performance and it can be very difficult to correct. Stratification can have many causes, but the most common are related to faulty maintenance practices.

Topdressing and turfgrass repairs can sometimes spread layers of fine materials, which over time develop into severe stratification problems. A 1/8-inch layer of fine soil is enough to block water flow in an otherwise perfect soil profile.

We sometimes see a succession of the layers, each further slowing the percolation process to the point where it can seem to stop.

Stratification is difficult to correct. Aeration and sand topdressing can help, but they must be done repeatedly to effectively correct the problem. Prevention is much easier and economical. ❑

Landscape Architect François Hébert represents Lanco Aménagement, 1110 Place Verner, Laval, Quebec, Canada H7E 4P2; phone: (888) 664-7489; fax: (514) 664-4555, e-mail: lanco@total.net.

Cutting-Edge Application Technologies

by Jim Puhalla

New technologies that are being referred to as injection methods have emerged for applying chemical agents to sports turf. These technologies include fertigation, hydro-jet injection, and drill seeders that drop solid material into slits.

Many of the new methods have produced positive results in field applications. The biggest hurdles to their widespread use are probably price and lack of knowledge on the part of fields managers. Let's try to remedy that knowledge gap.

Fertigation systems

Fertigation applies fertilizer or other liquid soil-enhancement products through an installed irrigation system. Chemical agents are automatically mixed into irrigation water from one or two reservoirs within the system.

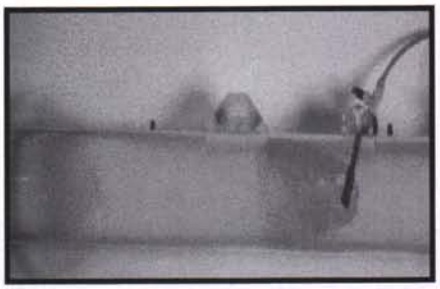
Some early fertigation systems have been abandoned because of clogging problems. Of course, liquid fertilizer tends to clog traditional spray equipment as well. These problems have not stopped companies from developing new generations of equipment.

Products that can be applied through a fertigation system include wetting agents, root enhancement products, and water treatment products that lower the pH of alkaline city water.

Fertigation equipment can add $3,000 to $7,000 to the cost of an installed irrigation system. However, according to David Hineline of North Coast Distributing, a fertigation system can save sports turf managers about 1/3 to 1/2 the cost of quality granular fertilizer.

Fertigation savings also show up in labor costs. A fertigation system obviously requires less labor than applying granular fertilizers with a spreader.

Labor savings can be especially significant on sand-based fields. The ideal fertilization schedule for a sand-based field is spoon-feeding: frequently applying small amounts of fertilizer. A fertigation system is ideal for this type of schedule.



The Toro NutriFlow Fertigation system uses an injector quill to distribute nutrients evenly into the lines of an installed irrigation system.
Courtesy: Toro

Fertigation systems are more cost-effective for large complexes than for smaller facilities with only one or two fields. Smaller operations may not recoup the cost quickly enough to justify the initial investment.

Of course, a fertigation system is only as good as the distribution uniformity of your irrigation system. If the system irrigates unevenly, fertilizer applications will also be uneven.

Hydro-injection

Another type of equipment called hydro-injection systems can be used for applying pesticides.

Hydro-injection uses a fine, high-pressure water jet to make a hole, and then injects material from a holding tank or bin through the turf canopy into the soil. The equipment can inject both liquid and solid products with minimal surface disruption. Most sports field applications can be ready for instant use.

Calibration is somewhat harder with dry material. Depth of penetration and the machine's ground speed must be considered. Calibration for liquids is easier, using gallons per 1,000 square feet as with a traditional sprayer.

Hydro-injection systems can also be used to aerate or inject sand and/or conditioner into turf. It is now being successfully used in Australia to inject fungicide.

These systems can cost upwards of $16,000, so most users in the near future will be hiring an outside contractor to provide the treatment.

Some manufacturers are now developing devices that will convert existing sprayers to injection-type units. These products promise a more affordable system.

Slitting injection

Another type of system uses stationary blades to cut slits in the turf. Behind each blade is a nozzle which sprays a stream of liquid into the slit. This technique is promising, but currently available models are very expensive.

A similar technology uses the same principles, but at a lower cost. It uses a drill seeder to drop solid material into soil slits through tubes. A roller then closes the openings. The typical cost of these units ranges from $4,000 to $5,000.

The University of Florida has performed extensive research on the use of this technology to control mole crickets, and has reported good results. The technology seems promising for grub control as well.

Technologies designed to deliver materials directly to the rootzone are showing substantial promise in early applications.

The initial cost of fertigation systems is probably most easily justified in large facilities. Slitting Injection equipment has the most immediate pay-back where widespread root-zone pest problems occur. Hydro-Injection technology allows frequent conditioning and treatment where surface disruption would be a problem.

All of these technologies require a major investment, but continuing research and development by industry manufacturers is bringing them within the grasp of more and more fields managers. ❑

Jim Puhalla is president of Sportscape International, Inc., of Boardman, OH, and Dallas, TX. He is author, with Mississippi State University Professors Jeff Krans and Mike Goatley, of a forthcoming book: Sports Fields — A Manual for Design, Construction and Maintenance. *Material in this article was adapted from that book.*

1 Dallas Morning News, August 3, 1997.