Analyzing Drainage Problems and Applying Proper Drainage Techniques January 6, 2004

I. Analyzing and Classifying Drainage Problems

The first step in solving drainage problems is properly identifying the type of drainage problem. Drainage problems may be classified into one of four major categories: (1) surface, (2) seepage, (3) collection, and (4) transportation. A surface water problem would be defined as any area where standing water or streaming water is a problem. A seepage water problem would be any area that presents a problem either after all of the surface water is removed, or is a problem even when no surface water was ever present. The ground remains saturated to the point that it interferes with either the mowability or playability of the hole.

Once the type of drainage problem has been identified, it is then necessary to determine whether or not the problem is due to the existing system's lack of ability to collect or transport water. For instance, if water was present in an area after a rain because of the trashing over of an undersized surface inlet, the problem would be defined as a surface water collection problem. If, however, the water was standing over a completely open inlet, but the water could not be transported off as the pipe size was too small to carry the volume of water present, it would be defined as a surface water transportation problem. The same analysis would apply to seepage water. Water that saturates the profile of the soil around a drainage basin that has solid sidewalls would be defined as a seepage water collection problem, but a USGA green being drained to a gravel sump that filled with water after a rain would be defined as a seepage water transportation problem.

All drainage problems can be defined within the parameters of the four classes described above. The key in golf course drainage is to realize that the problems are almost always a mixture of the above scenarios. Other than the isolated water puddle that stands on an impervious cart path surface, almost every problem in turf areas will have some aspect of more than one of the above categories. The key to designing an effective drainage system is building a system that will address both the surface and seepage issues present. Most drainage systems that fail do so because they are relying too heavily on surface inlets to collect seepage water, or trying to use seepage lines to collect surface water.

Designing a drainage system that delivers the maximum impact for the dollars spent requires recognition that the cost of collecting the same water can vary depending upon where it is collected. The least expensive water to collect is streaming or puddled water, while seepage water would be the most expensive. Sheet flow is collected at an intermediate cost between streaming and seepage water. For example, water that is flowing onto a fairway from houses constructed above a fairway may be coming from a hill in a relatively compacted stream. Placing a surface inlet directly in its path is much less expensive than waiting until the water dumps onto a fairway and is then turned into seepage water, as it loses velocity and infiltrates the profile.

II. Options in Drainage Designs

When designing a drainage system, multiple tools are available to collect and transport water. On the collection side, surface water is best collected with open inlets. However, tools such as berms, curbs, and v-drains can increase the effectiveness of the inlet by concentrating the sheet flow into stream flow, thus reducing the cost to collect. The least effective way to collect surface water is with seepage drainage and should only be used as a last resort. There are certain areas where one has no choice because of the unacceptability of catch basins in areas such as greens, bunkers, approaches, and athletic fields.

When it comes to seepage collection tools, there are seepage lines, permeable basins, and curtain drains. The common denominator is that they must have a permeability higher than the profile to be drained. In almost all cases, the installation of seepage drains in native soils will require the use of a sand backfill as opposed to gravel, which is the common procedure in the golf course industry. If a system is to stand the test of time, water must move into the system without carrying fines in the water stream. The basis of all seepage drainage engineering is a formula developed by Dr Karl Von Terzaghi, the “Father of Soil Mechanics”, at MIT in 1940. This formula determines the proper size backfill material in order to create a stable system. The objective in seepage drainage is to create a system where the water in the saturated soil can move to the drainage medium without having fines move with it. To do this, the 15% largest particle (d 85) must be stopped from moving with the water stream. If the 15% largest particles are stopped, then all of the smaller particles will be held in place behind it. The easiest way to look at this is in relation to the widely used USGA greens specifications. In 1993, the USGA revised the specifications for greens construction. One of the outcomes of this work was an alternative method to greens construction that allowed for the elimination of the choker sand layer[1]. By adopting the Terzaghi formula as the basis for their soil testing, they were able to justify the reduction of the particle sizes in the gravel blanket. One can imagine that if gravel needed to be downsized to match up to a typical greens mix, which is huge relative to most native soils, that the native soil will seldom match up to even a downsized gravel. Successful drainage systems will follow the guidelines of this formula in all installations, not just in the construction of greens.

Permeable basin used to collect seepage

Seepage water will be from one of three sources. The first is seepage water from lack of velocity. This is the only type of surface water that has the possibility of being collected with a surface solution, as this was surface water

[1] Snow, James T. March/ April 1993 "The Whys and Hows of Revising the USGA Green Construction Recommendations" USGA Green Section Record United States Golf Association, Far Hills, NJ pages 4-6

somewhere on the property, but entered the profile prior to reaching the area. Other possibilities include water that falls on such a flat area that the lack of velocity never allows it to stream off, or water that accumulates at such a low rate that it never forms surface water (i.e. irrigation or certain climates, such as the northwest, where mist is constant).

A second type of seepage water is water that has never moved onto the property as surface water (i.e. hillside springs). It was surface water somewhere, but there was never an opportunity to collect it as such. Now, the only option is to collect it as seepage. Third is water that is in the profile from a high water table (i.e. a coastal property with a fairway slightly above the controlling water level).

Additionally, a proper relief must be built for any drainage that is installed. Any drainage system is only as good as its relief. Any system that goes to a gravel sump is not drainage. IT IS A STORAGE COMPARTMENT. Not only should the reliefs be open and free flowing, but they should be of adequate depth so that they can serve as a relief for the seepage system, as well as the surface collection systems. Nothing is more wasteful than having to run a new relief parallel to an existing system because the existing system transporting the surface water was run at a shallow depth.

Three main choices exist when it comes to transportation systems: (1) conventional piping, (2) siphon systems, and (3) pump systems. Conventional piping simply involves installing pipe on a proper grade, and is by far the most common transportation system employed. Siphon systems are patented systems built by the Turf Drainage Co. of America and allow for the installation of drainage without the need to grade pipe. Siphon systems can provide shorter reliefs for large seepage systems, and enable the use of smaller equipment, such as trenchers instead of trackhoes. Siphon systems can also be used when the existing slope makes it impossible to build a conventional system that has enough water velocity to be self-cleaning. Pump systems can elevate water to elevations higher than that at which it is collected, and in many cases move water over obstructions or under streets less expensively than conventional reliefs. Pumps also can move larger amounts of water through a given pipe size, and can be used to create airspace for more effective seepage systems. These systems, when used in combination with check valves, can make it possible to drain any area, even one that might be at or below sea level.


Picture of siphon installation

Effective drain plans will use a different mix of these options, depending on the job site. Rolling properties will typically be almost exclusively conventional reliefs, while flat, coastal, or rocky properties will contain a larger percentage of the latter two choices. As a rule of thumb, no drainage installation should occur until a proper relief has been located or built that is at least 24” deep. The choice of deeper reliefs makes the entire system more effective with lower overall costs. Many systems will combine two or more of these transportation systems.

III: Designing the System

Lastly, the drainage system must be designed prior to the initiation of any work. The motto is, "plan when it is wet, and install when it is dry". Typically, it is best to plan all potential work before beginning installation phases. The alternative of planning a hole, installing that plan, then coming back and planning the next area, can produce a final product that has more overall transportation footage, and therefore higher overall costs. The reason for this is that a relief choice may be chosen to serve both areas, if all areas are planned from the beginning.

The planning process begins with the identification of each area to be drained, and recording its location. Next is the location of the optimal areas to collect surface water, as well as the tools to be used. No plan is complete at this point; any surface system will have areas that have missed water that now must be collected as seepage water, either from lack of velocity, or another type of seepage water as described above.

The seepage drainage design will be driven by the club's objectives. Objectives may vary in each area from removing unsightly puddles in an out of play area, to the desire to have the area in "tournament condition" as soon as possible once the rain has ceased. In light of these objectives, the design will have to answer the following questions:

How much? is another way to ask, What spacing should the lines be on? There are no absolutes. Unfortunately, no magical spacing exists that can apply to variations of objectives, soil types, shade, and budgets. However, suffice it to say that most installation occurs between 10 and 25 foot spacings.

How deep? Depth will be determined by soil type, water type, and the relief that is chosen. However, minimum standards would use 24" deep reliefs, and no part of any line will ever be less than 18". The most effective systems are typically between 22", with reliefs up to six feet deep. The most common question from the average green committee member is, "If our soil is only wet at the top, why do I need to go deep?" The lower the permeability of the soil, the deeper the column must be to create the hydraulic head to release water.

What direction? The lines should always be as perpendicular as possible to the flow of water. After that, the exact patterns will be dictated by the irrigation system, and the direction spoils will be moved. Typically, patterns that work perpendicular and parallel to irrigation systems will facilitate the least man hours to hand dig across irrigation lines.

What does it consist of? The best way to build technically correct seepage lines in native soils will almost always require the use of sands and geotextiles. Waffle type systems loan themselves to these construction methods and have a solid twenty year history in the golf course industry, not to mention other construction fields, such as highways.[2] Trenches are typically five to seven inches wide with the spoils cleaned and hauled away. Finally, backfills will normally utilize sands with infiltration rates of thirty to eighty inches per hour. These lines often are topped off with a mix that would have a higher percentage of moisture retention. Sodding of the trench line is recommended in most, but not all, cases.

The next step in the planning process is choosing the transportation system or combination of systems to be used. Once this is determined, along with the relief points, the length and size of the transportation line that will be required can be determined. At this time, the points the piping will intersect, and the fittings needed can be determined.

Lastly, all of these figures will be used to estimate the cubic yards of material that will need to be moved. This figure will be the basis for estimating total labor hours, the number of workers that will be needed, length of rental equipment, and the days the area will be out of play. Normally, in-house projects using plywood and shovels to move spoils will be between 1/10th and 3/10ths of a ton per man hour. Methods using overpacked trenches to facilitate spoils removal with loaders or skid steer equipment can move 8/10 to 1 ton per man hour. Experienced crews using tarp systems or conveyor trenches will typically move between 1 to 1.5 tons per man hour.

Tarp system for moving spoils

[2] Koerner, Robert M; George M. Koerner; Amira K. Fahim and Ragui F.Wilson-Fahmy 1994 "Report 367 – Long-Term Performance of Geosynthetics in Drainage Applications" National Copperative Highway Research Program National Academy Press, Washington, D.C.

DO:

- Build a system that is a combination of surface and seepage collection
- Run lateral lines as perpendicular to flow as possible
- Have the end of the system open and free-flowing
- Make the depth of pipe deep enough so that it can be used for both seepage drainage as well as surface water
- Backfill with sand, not gravel
- Make sure your reliefs are always protected
- Plan when it is wet, and install when it is dry

DON'T:

- Try to collect seepage water with surface basins
- Collect surface water with seepage drainage-unless there are no other options
- Use gravel sumps
- Allow water in a pipe to dump onto another part of the course

Misconceptions:

- Aerification will solve drainage problems
- Soil is only wet at the top, so a deep trench is not needed
- Low permeability soils cannot be drained
- Geotextiles clog up

Bilbliography

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Biographical Information

Dennis Hurley is President of Turf Drainage Co. of America. Dennis was the first person to introduce what is now generically called “waffle drainage” to the golf course industry at the GCSAA show in San Francisco in 1985. Since that time he has received four patents in the field of seepage drainage, and is the inventor of the Turf Drain Siphon System. In 2001 alone, his company was involved in drainage projects at four of the top twelve ranked golf courses in the country.