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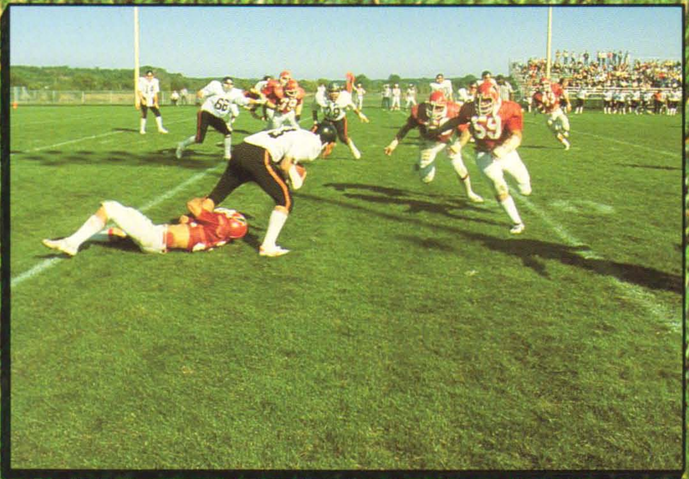
ATHLETIC FIELD CONSTRUCTION and MAINTENANCE



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ATHLETIC FIELD CONSTRUCTION AND MAINTENANCE

Spectators and players desire a dense, uniform and vigorously growing natural turfgrass cover for an athletic field. This cover gives sporting events an aesthetic appeal unequaled by other playing surfaces. A thick, consistent and smooth grass cover also improves playing quality as it provides stable footing for athletes, cushions their impact from tackles or falls, reduces muddiness during rainfall, and cools the playing surface during hot weather.

Properties of both the grass plants and the soil are important in establishing and maintaining a quality athletic field (Figure 1). Grass plants must be adapted to local climate and form a thick, dense cover at the desired mowing height. Athletic fields must tolerate intense foot traffic and shearing forces and therefore need grasses with reasonable wear tolerance and good recuperative capacity. Soil properties are of utmost importance to long-term turf maintenance. A smooth, stable surface helps prevent twisted ankles and more serious injuries which are too common during play. Soil-water relationships must allow adequate internal drainage and oxygen movement throughout the root zone. Adequate soil fertility levels are also essential to plant growth, but native fertility levels can be effectively supplemented by additions of fertilizer.

High quality fields require extensive planning and maintenance; they won't happen by chance. Proper decision making for athletic field maintenance starts before field construction. Poor soil conditions, improper drainage or other deficiencies built into a field make successful management impossible. Development of a quality field requires proper design and construction, suitably modified soil, careful establishment with appropriate grass varieties, and proper management practices after plant establishment.

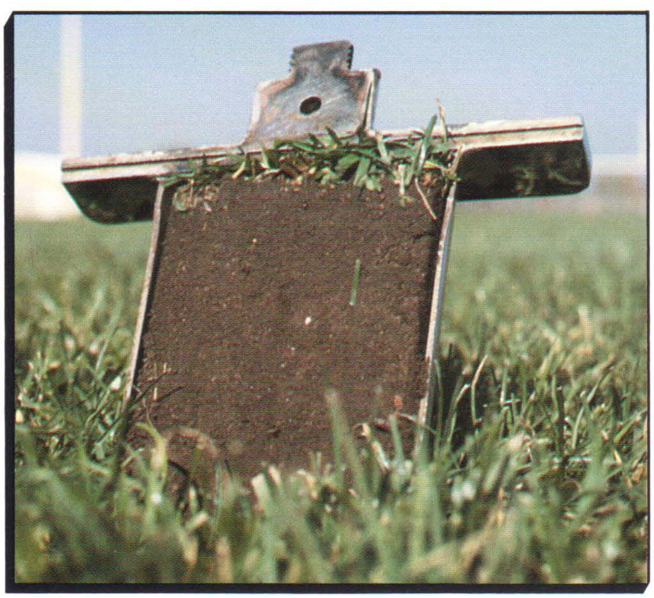

Figure 1. Plant and soil properties determine the quality of an athletic field.

This bulletin describes guidelines used successfully in Minnesota for construction and maintenance of athletic fields. Remember, however, that each site is unique, and careful consideration of site-specific information must be integrated with these guidelines for best results.

CONSTRUCTION OF A NEW FIELD

Early plans: Consider certain questions before beginning construction of a new field. Preliminary discussions between appropriate authorities and experienced professionals may be needed before deciding whether to undertake building a new field or to consider alternative options such as renovation.

A frank discussion of the issues by a school board, town council, park board or by private builders helps everyone understand problems involved, appropriate options, estimated costs, and procedures that lead to the best outcome. To make appropriate decisions, the initiating body needs testimony from knowledgeable soil and turf experts, contractors and others. Competent advice and counsel at this stage is crucial.

Questions to Address: After deciding to construct a new field, consider secondary planning issues. Are sufficient funds committed to the project? Are local or nearby contractors suitable and available? Are necessary soil and sand materials accessible? What site preparation is necessary? Is a water supply available for irrigation? Are drain easements possible? Even such considerations as the expected level of maintenance and expertise for the finished field's upkeep, or the estimated intensity of field use affect what soil and turf materials are recommended.

Determine a construction schedule; it is impossible to decide in December that you want a new field ready by June. In Minnesota, soil can be collected and its structure preserved only during certain seasons, usually summer or fall. Frequent precipitation and an uncertain soil drying schedule make spring collection and processing extremely risky. Late August is the most suitable time for planting grasses. Spring or dormant late fall seeding can also be successful but offers greater potential for problems than late summer or early fall plantings.

Construction Time Table: Before construction prepare a realistic time table for every operation, from writing specifications and contractor bids to field completion. Operations seldomly take less than a year to complete and often span two years. People unaquainted with the work involved are frequently surprised at the extensive timetable, and this timing has clear implications for fiscal budgeting.

Specifications: Obtain and refine specifications for grading, drainage, irrigation, soil materials and depth, grass species, seeding methods, fertilizers and maintenance until the contract period ends. Each of these may vary from site to site; modify available sample specifications to fit particular conditions of the field under construction and to make use of local soil and modifying components.

Field Dimensions and Orientation: The athletic associations involved determine design characteristics such as playing-field dimensions and markings. Construction must follow specifications found in the athletic associations' official rulebooks. Figure 2 on page 4 shows an example of dimensions specified for a high school soccer field.

If possible, orient fields to minimize time that players must look directly into the sun during games. Generally, in Minnesota the long axis of the field should be in a north-south or northwest-southeast direction. Where most play is at night and fields are well lit, orientation becomes less important.

Soil Profile: Soils for athletic fields present complex physical problems. These soils are subjected to concentrated traffic, often when soil is wet and most vulnerable to compaction. Natural soil structure at the surface is continually broken down and leads to compacted soil having poor water and air movement. This soil compaction inhibits water drainage out of the soil and reduces oxygen movement to plant roots, causing oxygen deprivation and death of the roots.

A soil profile that maintains good growing conditions despite frequent traffic offers a satisfactory solution to this problem. A method that has worked well is to excavate the soil to 14 to 16 inches below the desired grade, install a tile drainage system in trenches cut into the soil, and cover the entire field with 2 to 4 inches of coarse sand or very fine gravel. On top of the sand place 12 to 14 inches of a modified soil mixture that maintains enough large pores even after compaction to insure adequate drainage and air movement for root growth. Figure 3 shows a sketch of this profile.

Drainage: Prompt removal of excess water promotes optimal plant growth conditions and minimizes sports play disruption during periods of rainfall. When constructing athletic fields, supply both surface and subsurface drainage.

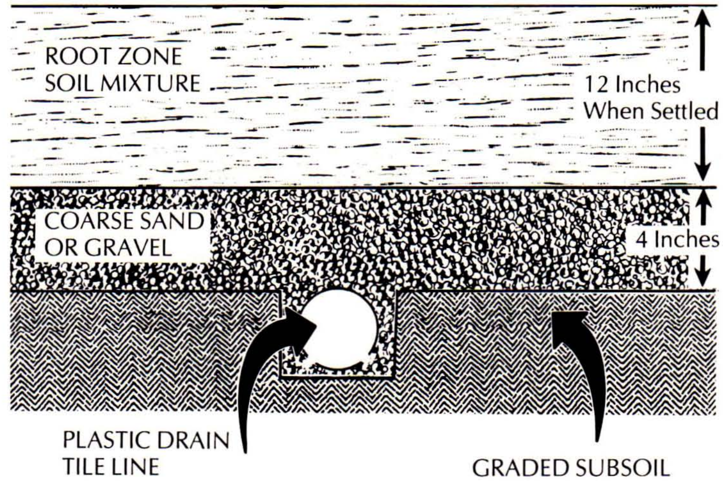

Figure 3. Vertical cross-section of soil profile recommended for athletic fields.

Surface drainage removes excess water that does not infiltrate into the soil. Surface drainage is supplied by sloping the surface slightly from the field's center to its sidelines. For most athletic surfaces, a slope of 1 to 1 1/2 percent is suitable and minimally affects play. A 1 1/2 percent slope on a football field is equivalent to a 15-inch crown running the field's length.

To remove the surface runoff from the field, install a trench along sidelines, outside the bench area, and at the lowest grade level. Place drain tubing in the bottom of the trench and then extend coarse sand to the surface to allow excess surface water to infiltrate quickly and be removed.

Subsurface drainage that removes excess water after it infiltrates into the soil is as important as surface drainage. After water infiltrates the soil, subsurface drainage removes excess water that would stop root growth by cutting off the oxygen supply. In most cases subsurface drainage is supplied through a system of flexible plastic drainage tubes. Drain tubing used for athletic fields commonly measures 3 to 6 inches in diameter.

Dig trenches for subsurface drainage lines at a depth where the top of the tubing will be at least 16 inches below the final grass surface. Trenches need to be only 6 to 8 inches wide and should have a uniform grade of 1 percent so that water will move rapidly to the system's outlet and prevent water pockets in trenches. Construct trenches to assure a uniform slope. Subsoil excavated from these trenches should be removed from the site to avoid plugged drain tubing perforations and to prevent the situation illustrated in Figure 4, where water does not flow quickly along the sand/subsoil interface to the drainage trench. The bottom of the trench must be clean, firm and of uniform grade. Tile or tubing can be placed directly on the bottom of the trench. Sand or very fine gravel can then be backfilled into the trench until it is 2 to 4 inches above the top of the trench. Exercise care during the backfill operation to insure that drain tubing remains in place at its original depth.

SOCCER FIELD

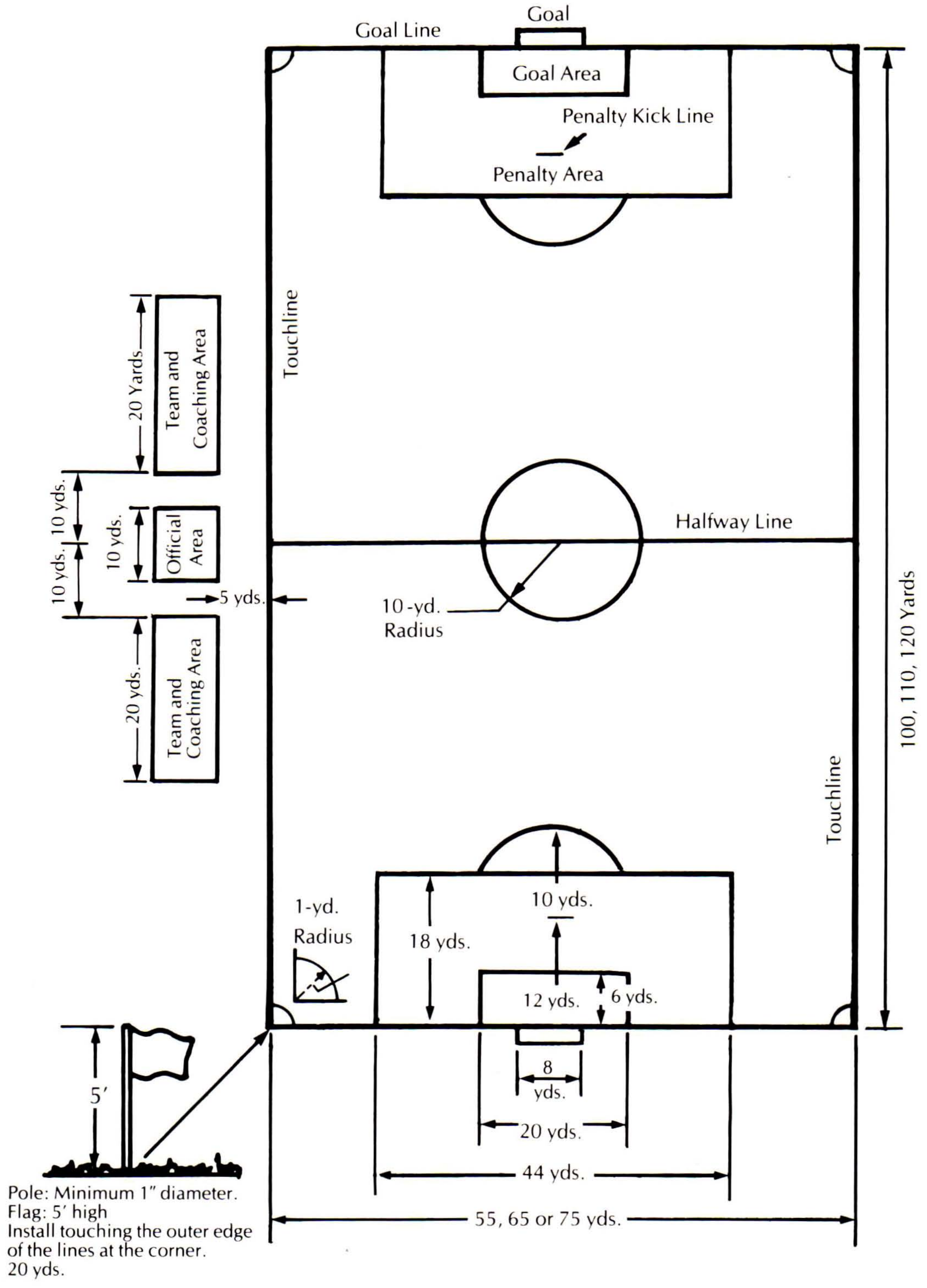

Figure 2. High school soccer field specifications (from 1984/85 Official High School Soccer Rules, National Federation of State High School Associations, Kansas City, MO)

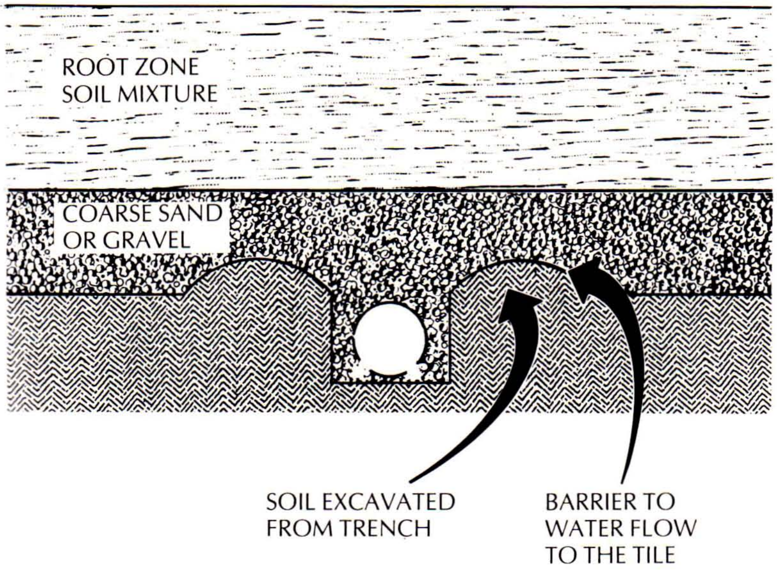

Figure 4. Diagram of soil profile shows problem caused by leaving soil excavated from tile line trench at the site. Water encounters a barrier of fine soil in its flow path to the trench.

Spread 2 to 4 inches of coarse sand over the entire field. During this procedure avoid driving construction equipment over drainage trenches because protection from crushing the plastic lines is not yet in place. This layer of sand serves several purposes. First, when the soil mixture above the sand becomes saturated, the sand allows excess water to rapidly move to the drainage lines. Second, when the soil mixture consists of distinctly different particle size compared to the sand, the sand allows more water to be held in the soil mixture above. Third, sand separates drainage lines from the soil mixture and thus prevents small soil particles from moving into the lines and possibly clogging portions of the drainage system.

Drainage lines throughout the system must have a continuous slope to the outlet. The outlet must be capable of handling the maximum flow expected through the drainage system. Otherwise, portions of the system, particularly those near the outlet, can become inoperative and cause soil to remain excessively wet.

SOIL MIXTURES FOR THE ROOTING ZONE

Deciding soil mixture specifications for the rooting zone is one of the most critical decisions of athletic field construction. The mixture must allow adequate air and water outflow to sustain plant growth even after compaction. Some water and nutrient holding capacity is also important to reduce the intensity of management required. Using soil mixtures with very high sand content generally achieves these requirements.

Most sands maintain large pores after compaction. These large pores allow water and air to quickly flow through the sand. By itself, however, sand retains very little water and almost no plant nutrients. Clay particles in soil and organic matter are the principal sources of water and nutrient holding power, but as the amount of clay and organic matter in a soil mixture increases, more large pores become blocked and water and air movement are impeded. The objective of blending sand and soil for athletic fields is to mix just enough clay and organic matter into the sand to give adequate water and nutrient retaining power without reducing water and air movement to a detrimental level.

The authors recommend starting with a washed sand of suitable quality and mixing in small quantities of soil and peat. Sand and gravel companies can inform you about their sands, but additional testing may also be necessary. An acceptable sand contains more than 60 percent particles between 0.25 and 1.0 mm in diameter (medium and coarse sand according to the USDA soil classification). This gives a relatively uniform sand with many pores of similar size, thus maximizing air and water movement through sand. Sand particles larger than 2 mm or smaller than 0.1 mm in diameter are undesirable and should constitute less than 3 percent of the sand by weight. Most sand suppliers list fineness modulus values for their sands; these values indicate the general fineness or coarseness of a sand. Sands with fineness modulus values between 1.7 and 2.5 are recommended for use in athletic field soil mixtures. Generally, a washed or size-graded sand is needed to meet these requirements. Table 1 summarizes these specifications.

Table 1. Specifications for sand used in athletic field soil mixtures.

Fineness modulus	1.7 to 2.5
Particles < 0.1 mm	less than 3% wt.
Particles > 2.0 mm	less than 3% wt.
Particles 0.25 to 1.0 mm	more than 60% wt.

Mortar or plaster sands that meet specifications in Table 1 are available at many sand and gravel companies throughout the state. Commercial sands vary considerably in particle size and suitability for soil mixtures; many are well suited and can be used with confidence but others should not be used. Concrete or coarse building sands, often available from the same companies, generally contain particles too large for soil mixtures. Sands used for specialized industries such as petroleum or sandblasting are sometimes available. Some of these sands are well suited for athletic field mixtures whereas others are not.

Soil used in the mixture should be free of herbicide residues, roots and stones. Texture can vary widely, but soils low in silt and very fine sand (0.002 to 0.1 mm diameter) are preferred. Silty soils used in mixtures often cause unusually low water infiltration rates and poor internal water drainage. Soils with silt contents exceeding two and a half times that of the clay fraction are not suitable. Soils having silt-to-clay ratios of 2.0 or less are preferred.

Peat used in soil mixtures must be high in organic content. Reed-sedge, hypnum or sphagnum peats are suitable if the organic content is greater than 75 percent by weight. Generally, muck soils are unsuitable, are usually detrimental, and are not recommended.

The amount of each component (sand, soil and peat) varies primarily with the texture of the soil component and may also depend on the depth of the soil mixture to be installed. If a 12-inch layer of settled soil mixture is laid over a coarse sand or gravel base, a soil mixture with 88 to 92 percent sand content by weight is recommended. Since the soil will settle, a 14-inch layer of loose soil mixture should be laid. Because the soil contributes sand to the mixture, actual mixing volumes of sand, soil and peat vary dependent on the sand content of the soil used.

Use Figure 5 on this page to determine the mixing volumes of sand, soil and peat needed to obtain a specified sand content by weight. Before using the graph you must know the sand content of the soil.

The following example illustrates how to use the graph. Suppose you want to have a soil mixture containing 88 percent sand by weight and the soil you intend to use contains 37 percent sand. Enter the chart on the left side at 37 percent and move horizontally to the 88 percent line, then move vertically downward to a sand volume of just less than four. Thus, a mixture of 4 volumes sand, 1 volume soil and 1 volume peat would give about 88.3 percent sand by weight in the final mixture.

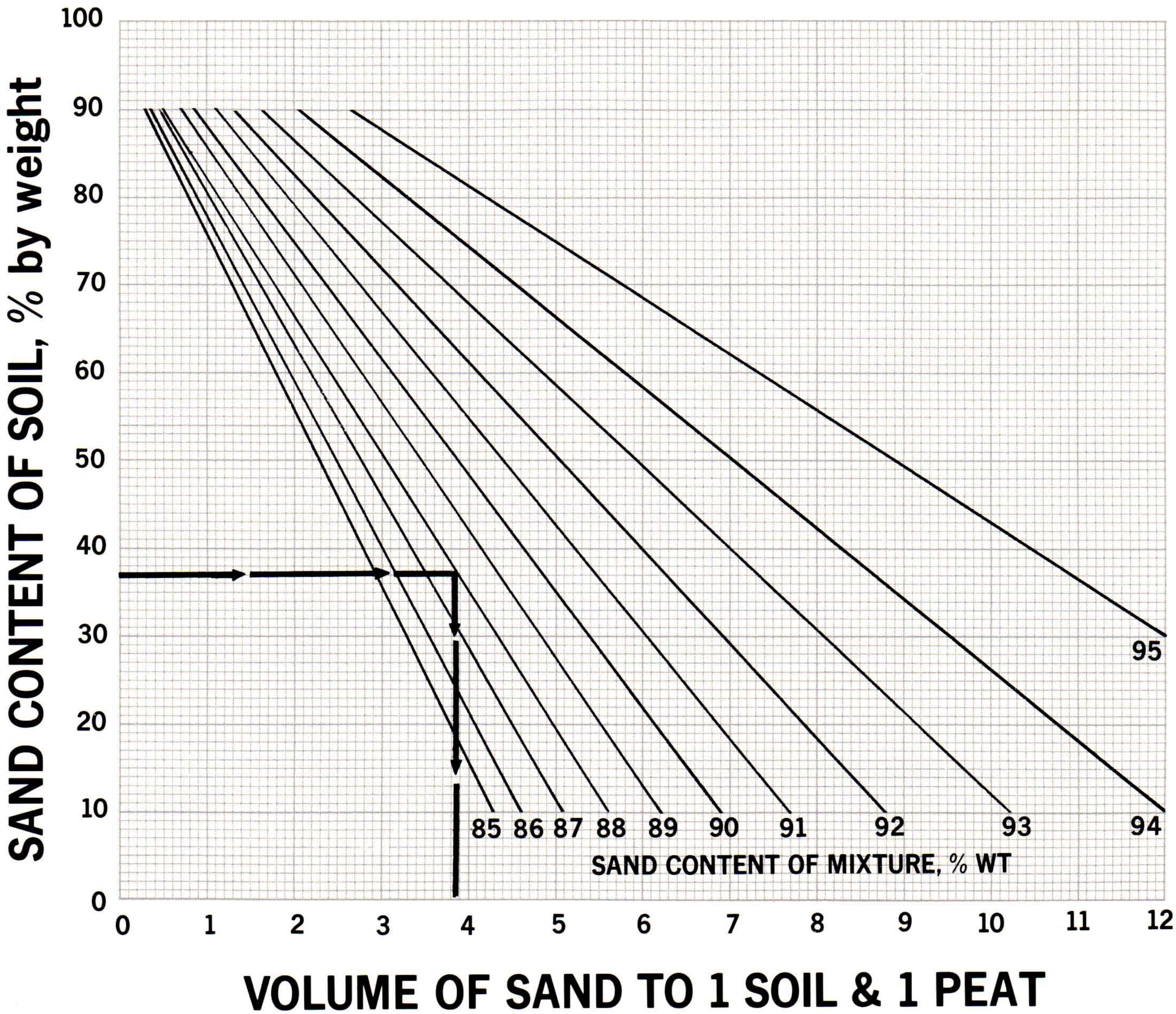

Figure 5. Nomograph to determine mixing volumes of sand, soil and peat for athletic field soil mixtures (from Taylor, D.H. and Blake, G.R. "Predicting sand content of modified soil mixtures from sand, soil and peat properties." *Agronomy Journal 76:583-587*).

Mixing soil with sand and peat: Mix sand, soil and peat only under conditions that insure a uniform mixing of ingredients. Mixing should be done off-site, away from or to one side of the athletic field site. Mixing sand and peat into existing soil generally gives a poor mixture even if the soil in place is a good one.

When mixing from precollected piles of sand, soil and peat, the shovel operator may need help deciding how to implement the volume-ratio specification. Determine with the operator the number of scoops per load of each component and instruct him or her of the need to obtain equal volumes of each. Occasional checking of the mixture by the soil specialist or architect during the mixing process helps determine if adjustments are needed. The most satisfactory equipment for off-site soil mixing is a mixer-shredder that accepts components and pulverizes, mixes and elevates them to a rotary screen prior to delivery (Figure 6).

Figure 6. A mixer-shredder to prepare soil mixtures for athletic fields.

Work or mix soil only at a moisture content that maintains natural soil structure. When mixed at a high water content, soil compacts, balls up and forms a non- uniform mixture. If mixed when too dry, soil tends to separate from sand or to remain cloddy, again forming a poor soil mixture.

Irrigation System: The decision whether to install an adequate irrigation system determines in most cases all other decisions; without the availability of irrigation, topsoil modification may become useless, and recommended grass varieties may perform poorly and alter post-establishment care. In Minnesota, irrigation is usually necessary for a high quality, wear-tolerant athletic field. Design the irrigation system according to site-specific soil properties and field layout. Consult staff from a reputable irrigation company when planning an irrigation layout; they frequently design a site-specific system at no cost. You may want to hire an irrigation engineer or landscape consultant to review the design and insure its adequacy.

Automated irrigation systems are widely available and used. High initial costs of these systems are compensated by reduced labor costs during the ensuing years. Uniform coverage of the entire field with awareness of prevailing wind conditions should be a prime consideration of any system whether automated or not. Several uncontrolled quick couplers at the field's ends are a helpful addition to automated systems for emergencies or miscellaneous tasks.

Install irrigation systems after modified soil is in place, and locate the lines at or below the modified topsoil layer.

Smoothing the soil mixture usually settles and firms it. In addition, an application of a heavy irrigation of 2 to 3 inches of water is a good practice to test the system and settle the soil mixture . Some fine grading can then be done before seeding.

Understand that a soil mixture with high sand content has a low available-water holding capacity. Consequently, without an adequate irrigation system this method of construction is unsuitable.

TURFGRASS ESTABLISHMENT

Preplant Fertilization: During finish grading, work phosphorus several inches into the soil mixture. Unlike nitrogen and potassium, phosphorus remains stationary in the soil so later surface additions move only a small distance into the root zone. If mixed into 3 or 4 inches of soil, add 25 to 50 pounds of super-phosphate (0-20-0) per 1000 square feet. At seeding time mix into the surface soil one-half pound of nitrogen and one-half pound potassium per 1000 square feet. After seeding, these nutrients can be applied as needed.

Seedlings are very sensitive to soluble fertilizer, so use caution when applying fertilizer before new seeding is well established. If soil tests show a sulfur deficiency, mix sulfur into the soil before seeding. Many sandy soil mixtures responded to 4 pounds sulfur per 1000 square feet. In all fertilizer applications use soil tests as guides to decide amount and kind of nutrient needed.

Grass Establishment: Kentucky bluegrass and perennial ryegrass are the two major grass species suitable for irrigated athletic fields in Minnesota. Kentucky bluegrass forms a dense, smooth and soft turf. Plants spread vigorously by rhizomes (underground stems) which help increase turf stability as well as speed recovery in worn areas. Since the leaves are soft, wear tolerance is moderate. Many varieties of Kentucky bluegrass have been developed and are available. The more vigorously growing varieties have higher wear tolerance and faster recovery than less vigorous ones. Other important characteristics include disease resistance and plant density.

Improved, turf-type perennial ryegrasses mixed with bluegrass are also well suited for athletic fields. Take care to select proper perennial ryegrass varieties, as only a few are sufficiently cold hardy for Minnesota's climate. Perennial ryegrass leaves are stiff and give excellent wear tolerance, however, ryegrass is a bunch grass that spreads and recovers less quickly than Kentucky bluegrass. If seeded too lightly the ryegrass forms a nonuniform, bunchy turf unsuitable for sports play. Essential characteristics of perennial ryegrass varieties include sufficient winter hardiness to tolerate Minnesota's climate and turf density compatible with Kentucky bluegrass.

Combining Kentucky bluegrass and perennial ryegrass yields a sports turf that possesses some of the wear tolerance of perennial ryegrass and the recuperative capacity and desirable playing qualities of Kentucky bluegrass. The authors recommend mixtures of 50 to 60 percent Kentucky bluegrass varieties by weight with the remaining 40 to 50 percent cold-tolerant perennial ryegrass varieties. The Kentucky bluegrass portion should be a blend of two to four vigorously growing varieties and the perennial ryegrass portion should be a single variety or blend of two cold-tolerant varieties. Seed the mixture at a rate of 4 to 6 pounds per 1000 square feet of turf.

For best results use a high quality seeder that uniformly distributes seed. A light drag such as a section of chain-link fence pulled behind the spreader mixes seed into the soil. Cover seed to a 1/4- to 1/3-inch depth. When seeding is completed, about 10 percent of the seed may be visible on the soil surface. Divide seed quantities in two, and sow half in one direction and the other half perpendicular to that direction. Figure 7 shows results of seeding in two directions with a seeder that drops seed into a slit cut in the soil, thus maximizing soil-seed contact.

Figure 7. Results of seeding in two directions with a slit seeder, soon after germination.

A surface mulch of straw or other material reduces the seeded area's drying rate and prevents movement of soil and seed particles. Winter wheat or rye straw usually has less weed seeds than spring-seeded grains. If you use a straw mulch, apply no more than 60 to 75 pounds of straw per 1000 square feet. Very light disking of the field with disks set vertically helps keep straw in place.

The best time for seeding in Minnesota is late August or early September when weather conditions are generally good for seed germination and grass growth. In addition, competition from weed growth is reduced and later eliminated by the first frost. In a field with irrigation, you may plant grasses in spring or summer but the potential for water stress, weed competition, seedling disease and excessive heat increases the risk of successful establishment.

After planting keep the surface moist during seed germination. This may require three or four light applications daily during hot weather. Deep irrigation is not necessary or even desirable, but water must be readily available near the seed; when germinating seedlings encounter water stress, they die very quickly. Gradually increase irrigation intervals once the slowly germinating bluegrass seedlings become established.

Begin mowing before seedlings reach a height of 2 1/2 to 3 inches. A 1 1/2- to 2-inch mowing height is preferred during the establishment period. Regardless of mowing height, remove no more than a third of the leaf height in a single mowing.

Fertilize lightly and frequently with nitrogen during this period. One-quarter pound nitrogen per 1000 square feet applied every two weeks should keep sufficient nitrogen available for vigorous establishment. Less frequent additions of slow-release nitrogen may be even better.

Weed control is difficult during the establishment period, as most herbicides damage germinating seedlings of desirable grasses more easily than established grasses. Apply herbicides after the first mowing, using half the label recommended rate until turf is well established.

Sodding is an unacceptable establishment method for athletic fields built with a sandy soil mixture. The soil mixture was developed to maintain large pores even after compaction, thus allowing water and air to flow at acceptable rates. A shallow surface layer of different soil brought in with sod can dramatically impede water flow and defeat the purpose of modified, sandy soil.

RENOVATION OF EXISTING FIELDS

Renovation vs Reconstruction: When a sports field is performing poorly, managers generally want to upgrade the field in the least expensive manner. Often they first consider renovating the existing field. Renovation is defined as field improvement beyond routine management practices but short of complete rebuilding. Carefully weigh major renovation against completely rebuilding the field; sometimes athletic fields are renovated at great expense but still fail to perform to minimum expectations. If it is to be beneficial, renovation should lead to one or more of the following:

1. improved surface drainage so that excess surface water flows off the playing area,
2. better internal drainage so that excess soil water can move rapidly from the root zone, and
3. better control of the timing and amount of water applied to the field and held in the soil.

Methods of Renovation: One of the simpler renovation methods is to simply regrade the existing field to achieve desired surface contours and thus promote adequate surface drainage. This renovation is particularly useful where growing conditions appear suitable except for depressional areas where excess surface water collects and remains for extended periods. Ponded water weakens turf and affects playing conditions. When regrading, establish a crown on the field's long axis and carefully grade a 1 to 1 1/2 percent slope toward the sidelines. Any accumulation of surface water then flows off the playing area.

An alternative approach is to use topdressing to establish a crown. Heavy topdressing applications in depressional areas and in the center of the field with lighter applications along the sidelines gradually give the desired surface drainage. Since it is a slow process, topdressing geared to change surface drainage is probably suited only to fields in reasonable playing condition but where surface drainage could be improved.

Another method of renovation is to modify the existing soil profile by adding modified soil or sand to the surface. Several methods can be used to achieve this, but the desired goal is always a surface soil mixture that maintains physical properties suitable for plant growth after compaction. If a high sand content is used to maintain these physical properties, remember that a small amount of sand may be worse than no sand. One experiment showed that 87 percent or more sand on a weight basis was needed to keep the soil mixture sufficiently porous for optimal grass growth. Thus, adding 4 inches of sand and tilling it with 2 inches of existing surface soil will provide an inadequate root zone soil mixture unless existing soil already has a high sand content. Internal drainage is as important as surface drainage, and if existing soil has poor drainage, a new root zone may do little to improve subsoil drainage.

Where internal drainage is acceptable, one approach to this renovation method is to strip the existing sod, add 4 inches of sand, and till to a depth of 6 inches (2 inches below the sand). Finish with 4 additional inches of sand and again till to a depth of 6 inches. Uniform mixing usually requires multiple tillage trips. Follow these soil modification procedures with final grading and establishment. A necessary prerequisite, the existing soil must have a texture that can be improved by adding sand.

Topdressing with sand or a very sandy mixture to build a new profile over the existing soil has also been applied in field renovation. Although some fields improved relatively rapidly, substantial improvement in growing conditions may take many years. Aerification combined with topdressing help to mix sand into the soil.

Another renovation method involves the removal of existing topsoil and replacement with a new soil mixture. Although similar to completely rebuilding the field, this method is sometimes called renovation when only the root zone is affected. Use this renovation technique when existing topsoil drains poorly but underlying soil has good drainage characteristics. Bringing good drainage conditions all the way to the surface improves growing conditions dramatically. Use a soil mixture that meets the same criteria as the mixture used in construction of an athletic field.

Upgrading or installing irrigation in an existing field: Irrigation is a necessity for optimal turfgrass plant growth in Minnesota. An athletic field with grass entering or breaking dormancy is particularly susceptible to damage from sporting events. An irrigation system can improve the quality of almost any athletic field, but without reasonable drainage properties in the soil it may lead to disappointingly small improvements or even localized drowning damage to turf. Consider all aspects of renovation when deciding upon irrigation improvement. For proper performance, design irrigation systems based on site-specific information rather than generalized plans.

Overseeding an Existing Field: Overseeding an athletic field should be a routine maintenance practice but is included here with renovation methods because it is perhaps the most commonly tried method of renovating sports fields. A key to successful overseeding is to get the seed down into the soil. Seedbed perparation is necessary for this to occur. One excellent preparation technique is aerification with hollow tines, which not only pulls soil to the surface but also relieves some soil compaction. To produce a better seedbed, make several passes over the field with the aerifier rather than limiting aerification to one or two passes. Following aerification, seeding in at least two directions with a seeder that cuts the seed into the soil offers the best chance for successful overseeding. Seasonal timing is just as important for overseeding as for establishing new seedings and is best done in late August or early September.

MAINTENANCE OF ATHLETIC FIELDS

Good maintenance practices are absolutely essential for a dense and wear-tolerant athletic field turf. Regardless of construction quality, poor maintenance leads to poor field conditions. Although this bulletin covers the basics of sports turf maintenance, study from the recommended reading list helps you obtain more details and stay abreast of current developments. Table 2 gives a general schedule of maintenance practices for athletic fields.

Table 2. Schedule for athletic fields.

March-April

Test soil for P and K requirements and pH.
Fill low spots and smooth surface.
Aerify as soon as soil is dry enough to work.
Vertical mow if thatch accumulation exceeds 1/2 inch.
Overseed bare or thin areas.
Begin mowing when grass is 3/4 to 1 inch above desired height.

May

Apply herbicide to control weeds if necessary.
Fertilize if growth is slow.
Aerify if soil compaction is occuring.

June-August

Irrigate only when necessary, wetting soil to 6 inches.
Mow regularly.
Fertilize in late August at 1 pound of nitrogen per 1000 square feet, P and K as needed.
Cultivate using slicer three weeks prior to playing season if necessary.

September

Spot seed areas receiving most wear.
Add nitrogen at 1 pound nitrogen per 1000 feet.

October-November

Aerify as soon as playing season ends.
Spot seed bare or thin areas.
Add nitrogen (1 pound nitrogen per 1000 feet) during latter part of October.

Equipment: Certain pieces of equipment are essential in managing an athletic field, whereas others make management easier but are optional. The following lists equipment according to their importance in sports field management.

1) Mower—The correct mower, sharp and well-adjusted, is imperative to sports field management. Both rotary and reel mowers are suitable for athletic fields. Reel mowers cut more cleanly, and when used in groups, cut a much wider swath than rotary mowers. However, they also require more maintenance. For a single athletic field, suitable mowers cut a 5- to 7-foot width. When additional large turf areas must be maintained, reel mowers cutting 11- to 21-foot swaths offer quick and efficient cutting.

2) Spreader—Apply fertilizer and granular pesticides with a spreader. A rotary spreader (Figure 8) offers quicker application and is preferable to a drop-type spreader. Although a small push spreader is suitable for single fields, larger units are much quicker and are essential if large turf areas are maintained.

Figure 8. Rotary spreader for application of granular fertilizers and pesticides.

3) Soil probe (Figure 9)—A simple, inexpensive soil probe helps determine important information about compaction, the depth of wetting by irrigation or precipitation, and soil moisture after drainage. It is also excellent for taking samples for soil analysis. You can purchase a soil proble cheaply or can make it with materials on hand, such as an old golf club.

Figure 9. A soil probe helps evaluate irrigation, compaction and root depth.

4) Core aerifier—An aerifier with hollow tines is a necessity for athletic field management (Figure 10). Aerifiers help open compacted surface soil and increase water infiltration. In addition, bringing soil to the surface prepares the field for overseeding and helps control thatch.

Figure 10. A core aerifier for athletic turf removes soil cores to relieve compaction and reduce thatch build-up.

5) Sprayer—A sprayer for liquid pesticide application provides an important aid when disease problems are present.

6) Seeder—A seeder which sows seed into slits cut into soil makes overseeding much more effective (Figure 11).

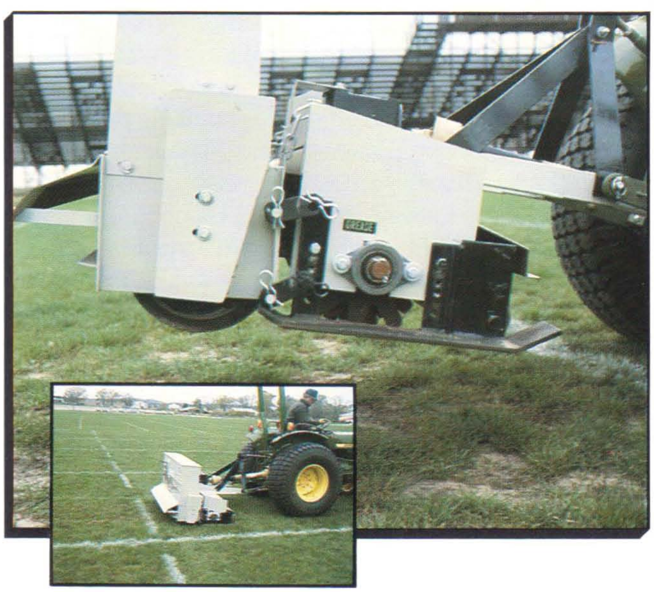

Figure 11. Slit seeder for initial establishment and overseeding.

7) Topdresser—Topdressing is the preferred method to smooth minor irregularities in field grade (Figure 12). It also helps control thatch development and can be used during renovation, as mentioned earlier.

Figure 12. Topdresser for surface application of thin soil layer.

Irrigation: Water management is an important component of athletic field care. Too much irrigation leachs essential plant nutrients from the root zone and leaves water ponded in low spots, whereas too little irrigation may lead to water stress and weak plants. If watering is too frequent, it promotes a shallow root system unable to absorb nutrients or water from deep in the root zone. Only general recommendations can be given here; each field is different and superintendents must be willing to experiment with irrigation rates and timing to determine characteristics specific to their field.

Plan your irrigation program to supplement rainfall, thereby aiding development of a deep and active turfgrass root system. This generally is best accomplished by irrigating infrequently and to a depth of at least 5 inches. After irrigation, sample several spots using a soil probe to determine how deeply you are wetting the profile. Based on sample results, adjust the irrigation period to provide sufficient moisture.

In a normal year evaporation plus transpiration from an athletic field in the Twin Cities area varies from about 1 inch per week in late May and early September to nearly 1 1/2 inches in July (Table 3). Exact amounts depend on particular weather conditions of a given week and the field's location in the state. Deduct expected rainfall from the normal evapotranspiration. Table 3 shows that in the Twin Cities you can normally expect to irrigate 0.6 inches of water for May, 0.9 inches for June, 2.2 inches for July and 1.4 inches for August. The general rule of thumb of 1 inch per week clearly supplies too much water. In summer months irrigation of 0.5 inches per week is more likely but may increase to 1.5 to 2 inches per week in a prolonged hot, rainless period.

Table 3. Average water use by turfgrass plants (evapotranspiration), rainfall and irrigation requirements for the Minneapolis-St. Paul area.

Period	Evapo-transpiration	Normal Rainfall	Supplemental water needed
	inches	inches	inches
April 1 to 15	0.9	0.9	0
April 15 to 30	1.3	1.1	0.2
May 1 to 15	1.7	1.4	0.3
May 15 to 30	2.0	1.7	0.3
June 1 to 15	2.2	1.9	0.3
June 15 to 30	2.5	1.9	0.60
July 1 to 15	2.8	1.7	1.1
July 15 to 31	2.7	1.6	1.1
August 1 to 15	2.5	1.6	0.9
August 15 to 31	2.0	1.5	0.5
September 1 to 15	1.5	1.3	0.2
September 15 to 30	1.1	1.1	0
October 1 to 15	0.8	0.8	0

In advanced stages of wilting, turf takes on a dull, bluish-grey hue and its leaves curl. Footprints remain visible as the leaves fail to bounce back where someone walked. Begin irrigation immediately when these signs appear. You can determine the proper interval between irrigations by careful observation of your field. On most fields one application per week is sufficient, though certain soils and weather stress periods may require more frequent application.

During the playing season, gear irrigation schedules to supply plant needs and for optimum playing conditions at gametime. Fields with less sand contents should be watered a sufficient time before the game to allow time for drainage and surface drying. This may take two or more days. Fields with high sand contents should be neither too dry nor too wet; experiment with your field to discover the best schedule. At the University of Minnesota Memorial Stadium, where the field had a high sand content root zone, a short irrigation early on the morning of the game provided ideal soil moisture conditions and secure footing by gametime. Irrigation also may be applied immediately following games if needed.

Mowing: Regular mowing of an athletic field contributes to a dense turf with minimal weed problems. Grass species, level of management, and desired field conditions affect the proper mowing height. Coaches usually like shorter grass than is desirable for good turf growth. Conduct a meeting of field managers and coaches and arrive at a desired height of cut to meet both turf and players' needs.

Improved, vigorously growing varieties of Kentucky bluegrass and perennial ryegrass perform optimally when mowed at about 1½ inches. Some of the older, lower-maintenance fields do better at a mowing height of 2 to 2½ inches. Shorter mowing provides a faster playing field with increased density and leaf growth rate but also promotes a shallow root system. Higher mowing provides a slower field with a deeper root system.

Schedule mowing to remove one-third or less of vertical leaf height. For example, if your desired mowing height is 1½ inches, mow before grass gets higher than 2¼ inches. If your mowing height is 2 inches, mow before the grass is more than 3 inches tall. Weekly mowing generally stays within these growth limitations. However, periods of excessive growth may require more frequent cutting.

Changing mowing height at different periods of the year is generally not required on an athletic field. If you wish to change the mowing height, reduce it very gradually to avoid removing excessive leaf area and scalping or weakening the turf.

Sharpen mowers frequently and check for proper alignment. Dull or misaligned mower blades shred leaf tips rather than cutting cleanly across the leaves. The shredded tips put extra stress on plants and reduce subsequent leaf growth.

Fertilization: The goal of fertilization is to insure sufficient nutrients for vigorous turfgrass growth throughout the year. Plant growth requires at least 17 elements, but most are present in sufficient quantity in the soil. Nitrogen, phosphorus, potassium and sometimes sulfur are elements that managers most commonly apply to supplement the native fertility.

To a large extent, nitrogen controls the growth of turf grass plants. An adequate supply of available nitrogen leads to a dense and vigorously growing, dark green, healthy turf. An excessive amount of nitrogen leads to a lush, dark green turf where leaf growth is overstimulated and occurs at the expense of root growth. This makes the field more susceptible to damage from disease, drought and traffic. A nitrogen deficiency leads to a slow-growing, light green or yellow turf that is slow to recover from traffic or other damage.

An athletic field usually needs about ¾ pounds of nitrogen per 1000 square feet during each month of vigorous growth. The timing and application rate needed to provide this level of nitrogen depend on the type of fertilizer used. Quickly available sources of nitrogen such as urea, ammonium nitrate and ammonium sulfate are water soluble and, for all practical purposes, are available to plants as soon as the chemicals encounter soil water. These nitrogen sources produce a sudden flush of growth followed by rapid nitrogen depletion as the grass uses the nitrogen or the chemical leaches through the soil. If applied at high rates these nitrogen forms have the potential to burn grass plants, especially during hot weather. Therefore, if you apply only quickly available nitrogen, apply it lightly and frequently (1/2 to 1 pounds nitrogen per 1000 square feet each month).

Slowly available nitrogen forms include sulfur-coated urea (SCU), isobutylidene diurea (IBDU), urea formaldehyde (UF), and activated sewage sludge (such as Milorganite). These materials all have different release characteristics and therefore timing and rate also vary. Generally, apply them at rates of 1 1/2 to 2 1/2 pounds nitrogen per 1000 square feet every two to three months.

Water newly applied fertilizer into the soil immediately, thus reducing both burn potential and the amount of nitrogen lost through volatilization.

Fields built on soil mixtures with high sand content are very susceptible to nitrogen leaching from over-irrigation or rainfall. Light, frequent applications are essential, adjusting the application to leaching potential. Research at several universities including the University of Minnesota suggests that nitrogen applied in autumn leads to a more healthy turf than when it is applied in spring. During late October and early November, top growth of grass plants slows but root growth continues. By applying nitrogen during this period, grass plants appear to develop stronger reserves than without the fall nitrogen application. Plants then become green earlier the next spring and avoid the flush of growth associated with early spring applications of nitrogen. Late fall nitrogen applications result in stronger root and rhizome development, earlier green-up, more uniform growth throughout the year, and less summer disease.

Spread fertilizer and all other materials carefully, particularly on athletic fields constructed with high sand-soil mixtures since native fertility and nutient holding capacity are very low. Figures 13 and 14 show an athletic field recently seeded and fertilized. The areas inadvertently missed during fertilizer application may take months longer to fill in and if not quickly corrected may drastically

Figure 13. Recently established field showing poor fertilizer application.

Figure 14. Close-up of field with poor fertilizer application. Unfertilized areas have a greatly diminished filling rate for grass in bare spots.

affect the field's playing quality. Knowledge of equipment, careful observations during application, and applying fertilizer in two directions can help avoid this problem.

Base the phosphorus and potassium recommendations on soil test results and maintain them at medium to high levels. Table 4 lists the recommended annual amounts based on soil tests by the University of Minnesota Soil Testing Laboratory.

Phosphorus is not mobile in soil and will not leach out of the root zone. Consequently, the timing of phosphorus

Table 4. Suggested annual phosphorus and potassium applications for athletic fields.

Phosphorus (P_2O_5)		Potassium (K_20)	
Test Results lb./acre	**Recommended Application lb./1000 ft.^{2}**	**Test Results lb./acre**	**Recommended Application lb./1000 ft.^{2}**
0-20	2	0-100	4
21-50	1	101-200	2
over 50	0	201-300	1
		over 300	0

applications is less critical than with nitrogen. Applied phosphorus is most available to plants immediately following application and gradually becomes less available. Therefore, late summer and early fall applications are generally recommended.

In finely textured soils such as loams, clay loams and clays, potassium is held on soil particles in a form available to plants. Very sandy soils like those used for athletic field soil mixtures have a low potassium holding capacity, thus potassium can leach out the root zone similarly to nitrogen. For sandy soils apply potassium on a schedule roughly the same as nitrogen application.

Sulfur application is not required on most native Minnesota soils, although a large area in north central Minnesota is deficient in native sulfur. Sandy soil mixtures may also lack sufficient sulfur supplies and frequently benefit from sulfur applications. Apply sulfur where needed at rates of 2 to 3 pounds sulfur per 1000 square feet yearly. The best sulfur carriers include sulfur-coated urea, ammonium sulfate or potassium sulfate which also supply nitrogen or potassium in your regular fertility program. Gypsum is another sulfur source widely available and easy to handle. You also may use elemental sulfur to supply the nutrient, but apply it carefully to avoid turfgrass leaf burn. Rates of sulfur should be no more than 1/2 to 1 pound sulfur per 1000 square feet for each application.

Other micronutrient deficiencies are generally associated with either excessive alkalinity or excessive acidity. Soil pH measurements help indicate possible problems. Turfgrass grows best at pH levels between six and eight. High-pH or alkaline soil mixtures are common in Minnesota and can lead to iron deficiencies. In such cases plants benefit from several foliar applications of 1 to 2 ounces iron per 1000 square feet per year. Nitrogen fertilizers such as ammonium sulfate have a slight acidifying effect and reduce soil pH as they supply nitrogen. Correct the low-pH or acidic soils with limestone applications.

Core Aerification: Soil compaction is a perpetual problem on any athletic field. Aerification that pulls cores of soil to the surface is the most effective method to alleviate surface compaction. Holes left by the aerifier allow both water and air to enter the soil even after soil cores break down and fill the holes. Regular aerification is a necessity in managing athletic fields.

Heavily used fields or those fields where soil is particularly susceptible to compaction may require four or more aerifications per year. During each aerification, run the aerifier several times over the entire field. Aerifier holes must be completely filled and turf healed before playing football or play could severely damage the field.

Soil cores on the surface as a result of aerification are generally worked into the soil by dragging a steel mat or section of chain-link fence across the field's surface after the cores are partially dry. An excellent time to apply a complete fertilizer is after late summer or early fall aerification and just prior to dragging. Dragging at this time helps get phosphorus into the root zone.

Aerification also helps control thatch layer development. As it pulls soil cores and works them into the surface, aerification mixes soil into the thatch layer and innoculates it with soil microorganisms that decompose the thatch, keeping it within tolerable limits.

Topdressing: Applying a thin layer of soil to the surface can help control thatch development and smooth the playing surface. Just as brushing aerification soil cores into the thatch provides faster thatch decomposition, applying a topdressing layer and brushing it into the thatch has a similar effect.

Unless topdressing is used to renovate a field as discussed previously, topdressing material should closely resemble existing topsoil. Layering different soils, particularly a finer-textured soil over a coarse-textured soil, reduces air and water movement and often limits root development.

You can topdress athletic fields with up to a 1/8- inch soil layer (just under 1/2 cubic yard per 1000 square feet) without reducing the growth of existing grass plants; a heavier application can severely reduce this growth. For thatch control and for maintaining a smooth surface, apply one or two light topdressings per year following core aerification. For renovation, more frequent and heavier topdressings are desirable.

Weed Control: A careful program of turfgrass management with proper maintenance practices and prudent herbicide use can effectively control most weeds on athletic fields. A dense cover of grass plants effectively controls weeds and should be the main emphasis in any weed control program. However, the constant wear and turf damage from sporting events generally requires herbicide use.

Broadleaf weeds can be grouped into those susceptible and those resistant to 2,4-D. Weeds such as dandelion and plaintain are susceptible to 2,4-D and can be effectively controlled with its use, but weeds such as clover, chickweed, knotweed and black medic are resistant to the herbicide and are best controlled by a combination of 2,4-D, MCPP and dicamba. In either case apply herbicide when weeds are small but actively growing, when temperatures are between 65 and 85 degrees Fahrenheit, when wind is minimal, and when rain is unlikely during the next 24 hours. Application at label recommended rates and according to directions is of paramount importance for chemical effectiveness as well as safety.

Control annual grass weeds such as crabgrass and foxtail with applications of preemergent herbicide very early in spring before weeds germinate. Several effective herbicides are available should be applied where significant annual grass weed populations grew in previous years. Postemergent herbicides to control these weeds after they are growing are available but generally are less effective than preemergent herbicides.

Perennial grass weeds such as quackgrass are most difficult to control. Presently, the only method is to apply herbicides that kill all grasses present and then reseed with desireable grasses. Glyphosate, available under several trade names, is particularly effective since you may reseed soon after herbicide application.

Knotweed poses another common weed problem as it comes up in early spring where the turf is thin. The weed emerges very early and competes aggressively against the grass seedlings you are trying to establish in these spots. Two approaches have been successful in controlling knotweed where overseeding is necessary. The first is to spray knotweed with glyphosate before seeding. Since glyphosate has a very short residual period, grass seeding can occur shortly after spraying. Note label recommendations and follow suggested waiting periods. (Remember, glyphosate also kills desirable grass plants.) The second approach is to spray knotweed with a herbicide combination of 2,4-D and MCPP. Again, use label recommendations to determine when you can seed after spraying.

Insect and Disease Control: Insect and disease damage may cause serious problems on turfgrass areas. Although infestations on Minnesota athletic fields have been infrequent, on occasion they have caused serious damage. Direct your treatments against an identified, specific insect or disease and check diagnosis with a competent authority. For the latest recommendations on weed, insect and disease control, contact your county agricultural extension agent.

Figure 15. A well-constructed, well-maintained sports field brings enjoyment to many people.

ADDITIONAL LITERATURE

A host of pamphlets and books provides sources for further study and gives updated material on recent developments. New equipment, new pesticides and improved cultural techniques are continually developed, and turf managers who do not keep current with these developments do themselves disservice.

In addition to materials available from your county extension office, a sampling of magazines and books directly related to sports turf management include the following.

Magazines

Golf Course Management. Golf Course Superintendents Association of America, 1617 St. Andrews Drive, Lawrence, Kansas 66046.

Green Section Record. U.S. Golf Association, Golf House, Far Hills, NJ 07931.

Grounds Maintenance. Intertec Publishing Corp., 9221 Quivira Road, Overland Park, KS 66215.

Park Maintenance. Madison Publishing Division, P.O. Box 1936, Appleton, WI 54913.

Sports Turf. Gold Trade Publications, Inc., P.O. Box 156, Encino, CA 91426.

Weeds, Trees and Turf. Harcourt Brace Jovanovich Publications, 1 East First Street, Duluth, MN 55802.

Books

Beard, J.B. *Turfgrass Science and Management.* Prentice-Hall, Inc., Englewood Cliffs, NJ. 1973.

Daniel, W.H. and Freeborg, R.B. *Turf Managers' Handbook.* Harvest Publishing Co., Cleveland, OH. 1979.

Emmons, R.D. *Turfgrass Science and Management.* Delmar Publishers Inc., Albany, New York. 1984.

Turgeon, A.J. *Turfgrass Mangagement.* Reston Publishing Co., Inc., Reston, Virginia. 1985.

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