TURFGRASS IRRIGATION MODULE

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Turfgrass Irrigation Module
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Turfgrass Irrigation Module for Golf Courses

Introduction

Water is a valuable resource for all Michigan citizens. Turfgrass irrigation is a very important maintenance practice on most of our golf courses. Although substantial volumes of water are utilized for golf turf irrigation, most is returned to groundwater. Still, it is incumbent on turfgrass managers to consider a broad set of activities in order to most wisely employ this resource.

Water conservation is achieved many ways. Proper maintenance and repair of an irrigation system reduces water wasted through leaks and improves application accuracy; intelligent choices in irrigation scheduling ensure efficient use; utilizing technological advances may enhance accuracy *and* efficiency.

This module was designed to help golf course superintendents evaluate their irrigation system and practices. This module will help superintendents improve the use of their current system, prioritize upgrades, and increase water conservation. It is intended to compliment the **Best Management Practices For Non-Agricultural Irrigation**, available at *http://turf.msu.edu/water.htm.*

The irrigation module for golf courses includes six sections. The sections are:

I. Inventory Assessment Worksheet: To determine the water needs of your course and to determine the appropriateness of specific water conservation measures, it is necessary to complete this worksheet. The information from the worksheet will be used throughout the BMP development process. The assessment will help turf managers to measure or forecast the effectiveness of various irrigation practices.

II. Self-Assessment: Several pages of questions that will help identify potential areas, tools, resources and practices that may be useful in developing BMP's for your facility.

III. Determining Irrigation Needs, Quantity and Timing: A review of potential reasons for irrigation, issues that affect application rates and timing, and special considerations for golf courses. *Other factors that influence scheduling can be found in the Conservation Practices section in Self-Assessment questions.*

IV. Potential Record-Keeping and Maintenance Forms: This section includes ideas for forms and worksheets that may be useful in the record-keeping and practical day-to-day maintenance of your system.

V. Design and Installation: Considerations for proper planning and implementation of irrigation systems.

VI. Irrigation Resources: External resources that you may find helpful in developing the Irrigation BMP for your course.

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Project GREEEN

I. Inventory Assessment Worksheet

This worksheet includes specific information that is needed to maintain and repair your system, and develop appropriate irrigation management practices and water conservation strategies for your course.

A. System Specific

YES	NO	N/A	
			Does your facility have an irrigation system as-built? This map should include: sprinkler locations, valve locations, pipe sizes, control wire/controller locations; sprinkler type and performance data, manual connections. It should identify play (g, t, f, etc.) and non-play (buildings, etc,) areas, and water features.
			Is your system control: • computer central (with ability to set for ET or water budget)?
			• mechanical central (with individual station control)?
			• field satellites? (includes wireless)
			• manual? (quick coupler or valve)
			Are sprinkler heads controlled: • individually?
			• by station (paired wires)?
			• valve (sectional)?
			Nozzle size and output is recorded for all sprinkler heads.
			Do you possess user/operation manuals for your system?
			Do you know the *current* pump station capacity? Use and wear reduce pumping volume. _____ GPM
			Do you possess p.s. maintenance and trouble-shooting guides?
			Do you have directions for winterization and start-up procedures for pumps and piping?
			Identify the water source and supply volume for your system: • Well, _____ GPM • Pond, _____ surface area; _____ depth *Circle pond recharge source(s)* i. Well, _____ GPM ii. Surface runoff iii. River/stream diversion iv. Groundwater • River/stream Direct intake, _____ GPM

In addition, it is advantageous to have the following information available in one location:

Irrigation system: date installed _____

brand/description _____

installer _____

number of field satellites _____

sprinkler heads:

type	*GPM*	*how many*
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

service technician _____

Pump Station: date installed _____

brand _____

installer _____

service technician _____

Pump specifications: HP _____

HP _____

HP _____

total pumping capacity _____ GPM

type vertical turbine *or* centrifugal

VFD _____

Pump station electrical supply and shut off located: _____

Pump station electrical schematics located: _____

B. Site Specific

List "averages" for each area:

- greens: turf spp._____, HOC_____, acres irrig_____
- tees: turf spp._____, HOC_____, acres irrig_____
- fairway: turf_____, HOC_____, acres irrig_____
- 1° rough: turf_____, HOC_____, acres irrig_____
- 2° rough: turf_____, HOC_____, acres irrig_____
- natural areas:

  cover type_____, HOC_____, acres irrig_____

YES	NO	N/A	
			Do you have a topographic map of the property and recognize areas susceptible to runoff? Topographic scale is commonly found on the irrigation system as-built.
			Do you know the general soil types, and areas of special consideration? (e.g. Mostly sandy loam with pockets of organic soil on #3 and 8.) Describe:_____ _____
			Do you know the green construction method? Describe:_____
			Drainage outlet locations are known and recorded on a site map.
			The system as-built identifies areas with special irrigation needs, (e.g. gardens, plant beds) AND areas with no irrigation need (e.g. hardscapes like buildings and parking lots, or natural areas and aquatic habitat).
			Well logs have been examined for subsoil descriptions. This information enhances knowledge of drainage and aquifer recharge considerations.

II. Self-Assessment: Identifying Potential Areas for Enhancement

A. Usage and Programming

Management Responsibility

YES	NO	N/A	
			Management responsibilities (scheduling, evaluation, and repairs) for the irrigation system have been assigned.
			System managers have received necessary training on proper use, operation and capacity of the system.
			System managers have received necessary training to adjust or shutdown the system based on prevailing or impending weather conditions.
			The system managers stay current with technological improvements and implement those that optimize efficiency and the conservation of water.

Scheduling

YES	NO	N/A	
			A base irrigation schedule has been established to determine the initial frequency of operation.
			The decision to irrigate is made daily. The schedule is based on turf health and playing conditions.
			Application rate (run-time) is determined by: • ET calculation, on-site data • ET calculation, off-site data • Soil moisture probing • Visual observation • Weather prediction • Accounts for daytime water use (syringing, watering in applications, etc.) • Considers pest pressure
			The irrigation cycle is designed to prevent runoff (water application rate does not exceed soil infiltration rate). Observe for the presence of puddles during and after irrigation cycles.

			The irrigation cycle maximizes output to compress "water window," and takes advantage of "off-peak" electricity costs. • With stand-alone satellite control, maximize system efficiency by producing a manual flowchart (*see "Creating a Manual Flowchart" at end of module).* • With central control, utilize efficiency features. • With computer central programming, know the software features to maximize system efficiency.
			(With computer central programming) programming software is used to help calculate irrigation rates.
			All schedule changes and data entries are *double-checked!*
			(With a manual system) the irrigation application technician clearly understands instructions and knows the system limitations, and uses tactics that reduce runoff.

Monitoring

YES	NO	N/A	
			Central control *computer* is checked after each irrigation event. (Did the system run as expected?)
			A field check is performed *after each irrigation event* to evaluate the effectiveness of the schedule by assessing plant health and soil moisture. Adjust the irrigation schedule to avoid applying excessive irrigation water.
			Pump station is checked daily. • Water-use record is reviewed after each irrigation cycle to monitor for excessive water use, indicating potential leaks. Rapid pressure loss from system, during non-watering periods, may also indicate a leak. • Control panel is checked for electrical faults or errors. • Station is inspected for physical damage or leaks. • Listen for unusual sounds in pumps and piping.
			The proper operation and performance of irrigation components is routinely verified. Test system by initiating schedules through central control. Advance through programs and observe response by field components. This field check should be completed *several times per season.*

Record keeping

YES	NO	N/A	
			Changes or repairs to the irrigation system are recorded.
			A manual record of station run-times is kept, in case of problems with central control.
			A record is kept of the volume of water used *every month* the system is running. The system manager should also note water use after each irrigation event.
			The system manager, or designee, submits all mandated reports when required to do so. • DEQ Water Use Report (yearly)

B. System Maintenance

YES	NO	N/A	
			A daily field check is done to look for system leaks and problems.
			Minor repairs are made quickly (i.e. replace gaskets, nozzles, weepers, etc., same day found). Spare heads and common repair parts are kept on hand.
			Turf around sprinkler heads is trimmed once every six weeks.
			Obstructions to proper sprinkler head distribution (e.g. trash cans, branches, benches, signs) are quickly remedied.
			All heads are tested from central control several times each year.
			Water is applied only where needed; overthrow onto hardscapes, natural areas, etc., is avoided. Part-circle heads or smaller nozzles are installed and individual heads turned off as needed.
			Satellite controller stations are rewired to group heads with similar irrigation requirements (e.g. dry vs. wet areas, shady vs. sunny, hillsides, bunker banks).
			Test equipment is available for trouble-shooting electrical and wiring problems.
			Satellites are inspected for pest problems at least three times per season (use ants traps, mothballs, etc., as needed). Satellite pedestals are securely fastened and lockable.
			Ground resistance (grounding) of pump station, field satellites, supply wells, and other components is checked at least once per season, or after lightening strike or significant electrical surges.
			Communication and power wires are checked periodically. • Find field splices and inspect. Install a valve box over splices when possible. • Examine wiring at entry points to buildings and satellites. • Know what happens if communication or electricity is lost - default set-up of system control *and* pump station.
			Proper winterization procedures are always followed.
			Proper spring start-up procedures are always followed.

C. Conservation Practices

YES	NO	N/A	
			A decision to irrigate is made *daily*, based on turf requirements and anticipated weather conditions.
			Course conditions are observed after every irrigation event to evaluate turf conditions and water use efficiency. Irrigation schedule is modified accordingly.
			Schedule takes advantage of "cycle and soak" programming features where water requirements exceed infiltration rates
			Cultural practices (e.g. mowing height, dethatching, aeration) are used to improve infiltration rate and maximize water use efficiency.
			Wetting agents and/or soil amendments are used to improve soil moisture balance.
			Nutrients are applied to maximize turfgrass vigor and minimize excess shoot growth.
			Supplemental hand-watering is used to precisely apply water only where needed.
			Irrigation system is connected to rain sensors that automatically suspend irrigation cycle.
			Local, or on-site, weather station data is used to accurately determine ET.
			Drought tolerant plants are used where possible.
			Pump station controls include "flow monitoring and management" to minimize water loss from catastrophic irrigation system leaks.
			The tactic of "deficit irrigation" (i.e. applying less than 100% replacement of daily ET) is employed to reduce water use.
			A water audit has been performed on the system. • In-house or contractor • Small sampling of system • Large sampling of system • Problematic area
			Sensors are used to monitor soil moisture.
			The system includes alternative water delivery technologies (e.g. drip or weep systems) for difficult-to-irrigate areas.
			Reclaimed water is used for irrigation.

III. Determining Irrigation Needs, Quantity and Timing

Proper irrigation requires thoughtful decisions based on knowledge. You must first know the site and the system to effectively irrigate the turfgrass and conserve water. It is important to periodically review your reasons for irrigating, factors that influence application rates and timing, and special considerations for golf courses.

Why, How Much, and When to Irrigate

- Determining golf turf irrigation needs *(do I need to water?)*
  - What is your goal? Turf survival, playability, aesthetic quality?
    - Each playing surface, turf type, and height of cut may have different goals. These goals may vary from day to day.
  - Visually assess turf quality
  - Evaluate soil moisture (by feel, or with tools)
  - Review evapotranspiration data
  - Consider current weather conditions and predictions
  - Other tools

- Estimating application/run times *(how much will I apply?)*
  - Use evapotranspiration data to calculate replacement volume
  - Know sprinkler head precipitation rates and spacing
    - Use performance data from manufacturer
    - Perform water audit (catch-can test)
  - Monitor depth of rootzone and recognize seasonal variations
  - Be aware of soil types and their infiltration rates
  - Understand microclimates (tree competition, wind, humidity, etc.)
  - Recognize topographic challenges
  - Consider the impact of other water inputs (daytime hand-watering, watering-in of fertilizer and topdressing, etc.)
  - Utilize "cycle and soak" programming features where water requirements exceed infiltration rates

- Establishing irrigation cycle timing *(when is the best time to water?)*
  - Determine length of entire cycle (depends on application rates and system capacity)
  - Customer considerations (drift onto entry walks and driveways, and gathering places; driving range clean-up, etc.)
  - Play considerations (tee times, tournaments, outings, etc.)
  - Consider the impact on other maintenance practices (morning mowing, cultivation, spraying, etc.)
  - Identify time of day with least wind movement
  - Coordinate with time of "off-peak demand" electricity rates
  - Recognize that duration of leaf wetness may affect disease development

Special Considerations

- Special concerns of putting greens
  - ball roll
  - very short roots
  - *Poa annua* control or management
  - flushing a perched water table
  - localized dry spot
  - moss/algae development
- Daytime/manual hand watering and syringing
- Special watering needs
  - leaching salts from the root zone
  - settling granular fertilizer applications and topdressing
  - moving chemicals into the proper zone (depth) for efficacy
  - application of bio-controls (e.g. Bioject)
  - application of wetting agents, fertigation
- Disease management
  - The duration of leaf wetness has an impact on development of some turfgrass diseases. Minimizing this period can help to manage these diseases, thus reducing the need for fungicide applications. Whenever feasible, run the irrigation cycle as close to dawn as possible.
  - Excessive soil moisture and standing water can exacerbate development of some turf diseases, especially with hot and humid conditions. Under such weather conditions, or predictions, reduce irrigation rate and/or frequency.

IV. Potential Record-Keeping and Maintenance Forms

Many turfgrass managers find it beneficial to use checklists and forms to help them with record keeping. Checklists are a great way to create standardized operating procedures for tasks that you may not perform on a regular basis, or are done by several individuals. The following is a list of potential forms, checklists and worksheets that you could create and customize for your specific property.

- Daily checklist
- Monthly checklist – "To do" lists for routine irrigation system maintenance.
- Seasonal checklist

- Monthly Water-Use Log – Keep handy, near the pump station water-use report. Useful for year-end reporting.

- Changes/Modification/Repairs Form – Work record to be used in the field. System manager should document all changes on the as-built, when changes are completed.

- Irrigation System Alert Form – Standardized form for recording observation of an irrigation system problem or work needed; investigation required.

- Calculating Precipitation Rates – Catch-can test record worksheet.

- Manual record of run-times or run-time adjustments – In case of central control problems.

- Evapotranspiration Record or ET Calculation Sheet – Record ET values, or data for manual calculations.

V. Design and Installation – New Systems and Renovations

System planning for efficient and uniform distribution of irrigation water

- The spacing of the sprinkler head should be based on manufacturer's recommendations.
- Assure that the design will match precipitation rates of sprinklers within a control zone or group.
- All plants within a zone should have similar water requirements and root depths.
- Keep sprinkler base pressure within manufacturers recommendations
- The use of drip or micro irrigation will help to minimize runoff and water drift on to hardscapes.
- Include in the design water conserving technology, whenever economically feasible.
- Sprinkler head location should take into account possible obstructions.
- The use of pressure compensating materials in the system will maintain water distribution uniformity throughout the zone.
- Both the design and the installation will incorporate appropriate pipe sizing throughout the system.
- The size and pressure of the specified water source shall be adequate to meet the peak demands of the system within a specified watering time window.

System integrity

- The system must be installed per the design and specifications to insure maximum efficiency and compliance with the designer's intent.
- The owner or the owner's representative will determine acceptable experience and qualifications of all potential installers.
- The installer will insure qualified supervision of the installation process.
- A qualified and authorized individual shall conduct final inspection and approval of the system.

As-built, documentation, operation manual creation and system orientation with owner/manager

- A set of actual construction drawings, updated daily by the installing contractor and clearly annotated shall be kept during the construction process. This final As-built document should include the locations and sizes of the water meter, shutoff valves, backflow prevention device, mainline pipes, zone valves, lateral pipes, sprinklers, controller locations and sensors should be provided.
- Provide all manuals and instructions sheets to the owners designated representative.
- A written manual of suggested maintenance of the system, including winterizing and start up procedures shall be provided.

Priority List for Turfgrass Irrigation Best Management Practices

Review the worksheets and checklists from the Inventory and Self-Assessment sections and identify your top three priorities for improving irrigation usage and water conservation.

1.

2.

3.

VI. Irrigation Resources:
Water Conservation Gadgets

Items used to conserve water on turfgrass applications:

Weather Stations
Rain sensors
Freeze sensors
Wind sensors
Climate based control systems
Flow monitoring and management
Low volume/low pressure sprinklers
Soil moisture sensors
Pressure regulators
High-flow branch cut-off
Warning notifications and remote call-out capability

On-line Resources:

Water Right (*www.turfgrass-sod.org*)

Irrigation Association of America (*www.irrigation.org*)

Smart Water Irrigation Technology (SWAT)

GCSAA EDGE (*www.eifg.org*)

USGA Green Section (*http://www.usga.org/turf/index.html*)

MTESP Water Page (*www.turf.msu.edu/water.htm*)

Creating a Manual Flowchart – for systems without central control or linked satellites

1. Obtain run-times for all field satellite stations.

2. In each field satellite, categorize the stations to create programs (a sequence of stations using the same start time) for greens, tees, fairways, rough, etc.
   - This will be limited by the number of programs allowed by your satellite. Mechanical satellites may only allow for one.
   - Try to restrict to four programs for simplicity.

3. Total the station run-times for each of the programs in every satellite.

4. Estimate the GPM of water required for each station.
   - This may vary depending on number of heads per station, and type of head or nozzle.
   - To avoid a water demand that exceeds system capacity, estimates should be generous.
   - Stations in the same program should have similar water flow rates.

5. Create a program information chart to help you diagram flow demand (see example below)
   - Hole numbers along left side of page; program identification along top of page.
   - At corresponding intersection of "hole" and "program," fill in:
     i. number of stations in program and average run time
     ii. duration of all station run-times for that program (e.g. five stations each run about 10 minutes = 50 min)
     iii. estimate average GPM flow of stations in program (round up to nearest ten)
     iv. leave a blank space for start time

Sample Program Info Chart

HOLE #	Greens program	Tee prgm	Fwy prgm	Banks prgm
1				
Start time				
Duration	50 min	3 hrs	7:40 hrs	32 min
Sta/prgm	5 (10 min each)	9 (20 min)	23 (20 min)	4 (8 min)
GPM/sta	50 gpm (1 head/sta)	100 gpm (2)	100 gpm (2)	50 gpm (1)
2				
Start time				
Duration	40 min	1:15 hrs	1 hr	24 min
Sta/prgm	4 (10 min each)	5 (15 min)	3 (20 min)	3 (8 min)
GPM/sta	50 gpm (1 head/sta)	100 gpm (2)	100 gpm (2)	50 gpm (1)
3				
Start time				
Duration	40 min	3:20 hrs	5 hrs	24 min
Sta/prgm	4 (10 min each)	8 (25 min)	15 (20 min)	3 (8 min)
GPM/sta	50 gpm (1 head/sta)	100 gpm (2)	100 gpm (2)	50 gpm (1)

6. Identify the longest running program (probably a par 5 fairway) and at what time the irrigation cycle must be completed. Keep in mind that "early" holes must be ready at the first tee time, but finishing holes can continue running for an hour or so after the first tee time.

7. Using the longest duration program (and/or a large fairway near the beginning of the round), estimate an initial start time for the irrigation cycle by subtracting the program duration from completion time (e.g. #1 fairway takes 7:40 to run and needs to finish by 6 am. Must start by 10:20 pm.)

8. Create a flow demand graph (see example below)
   - Hole numbers down left side of graph
   - Hour of the day across top (span of time should match potential water window – generally 8 pm to 6 am.).

9. Draw a horizontal line for the program identified in step 7, to represent the run-time duration of that whole program. This line also represents the GPM demand of that program (in this example, 50 gpm for greens and banks programs, 100 gpm for tee and fairway programs).

10. Add other programs to that initial start time until system demand is *near* capacity. The demand should remain below maximum capacity, to accommodate heads stuck on, minor leaks, or incorrect data.
    - Stagger adjacent start times by one or two minutes, to slowly ramp-up to system capacity and avoid over-drawing the pump station.
    - Be sure to accurately track the various GPM flow rates of different programs (e.g. 50 gpm for greens and banks programs, 100 gpm for tee and fairway programs).

11. As one program finishes, set a new start time and draw a line for another program.
    - This will utilize the pumping capacity of system most efficiently, and minimizes water window (duration of entire cycle).

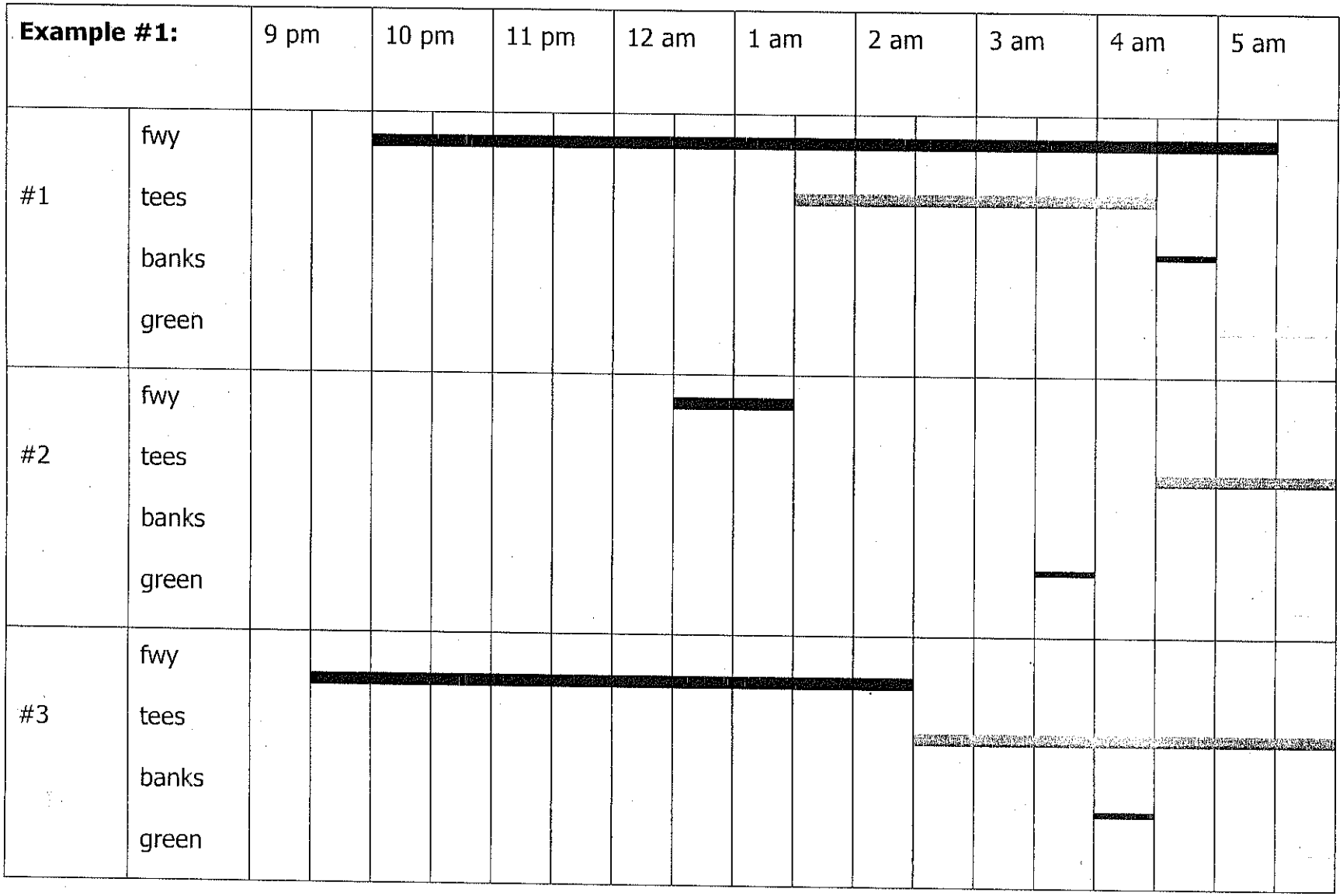
12. Balance the water demand on the supply pipes by alternating start times between front nine and back (or other logical division of underground supply lines).

13. Due to run-time duration and disease concerns, fairways are usually scheduled first (to run in early evening), greens are scheduled second (to finish close to dawn), and tees, banks, etc., are used to fill in low demand times.

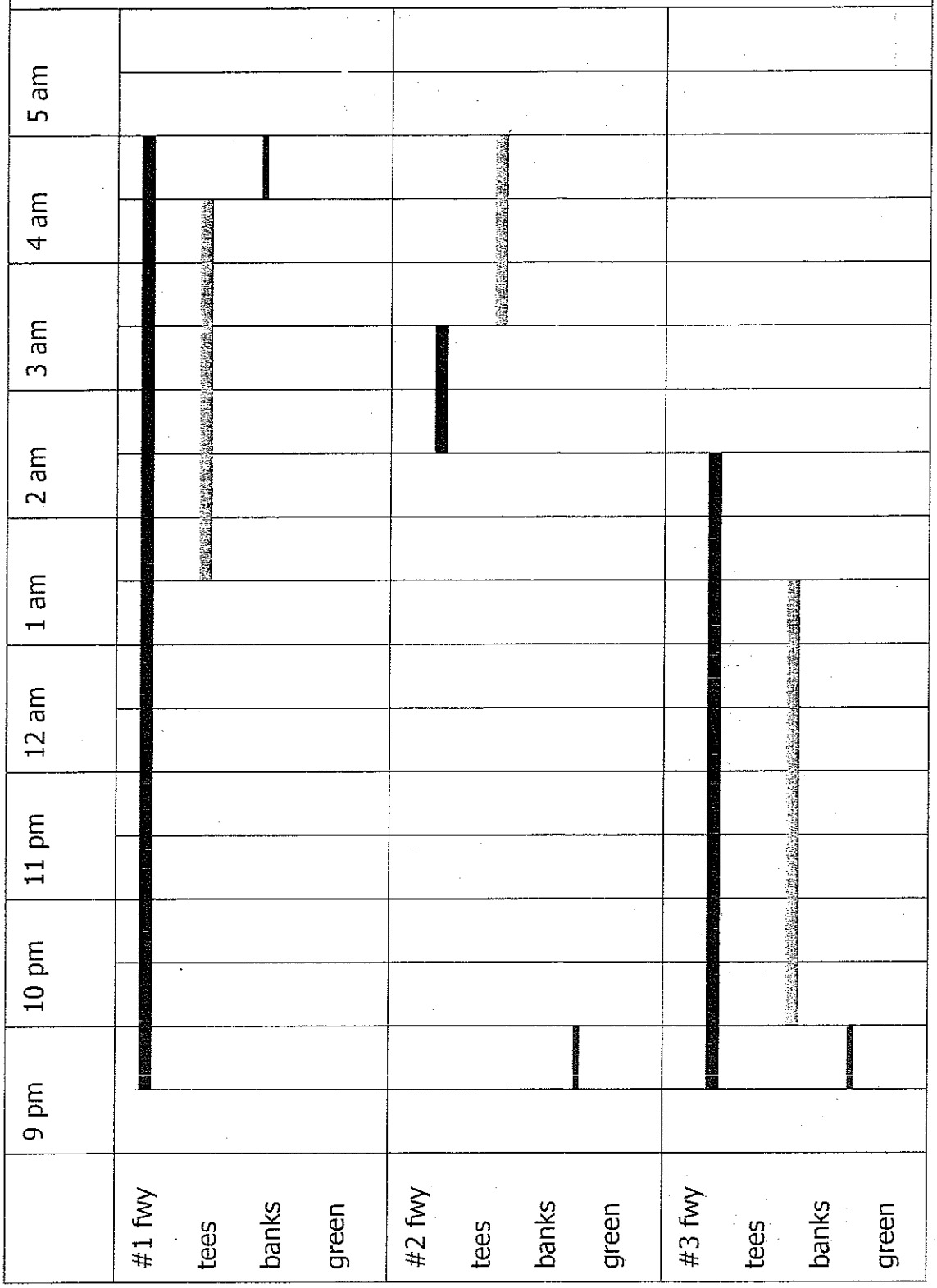
14. Use pencil to mark the duration lines (lots of changes as you develop schedule). Colored pencil is pretty, but not necessary.

Example #1: Assume this 3-hole golf course has a *rated* pumping capacity of 500 gpm, has three field satellite controllers, and allows only two programs to run at a time out of any one satellite. The superintendent makes it a priority to irrigate as close to dawn as possible. The system is old and worn, so *actual* pumping capacity is probably 400 gpm.

At 930 pm the system is running 100 gpm. At 1030 pm, it is running 200 gpm. At 1 am, 300 gpm. At 4 am and 5 am (depending on exact start/end times), the system could be running 350 - 400 gpm. And just before all irrigation ends at 6 am, there is 350 gpm flowing out of sprinkler heads. When demand exceeds 350 gpm, pressure loss may cause poor distribution. This theory should be tested before irrigation cycle is allowed to run.


Example #1:
9 pm
10 pm
11 pm
12 am
1 am
2 am
3 am
4 am
5 am
#1
fwy
tees
banks
green
#2
fwy
tees
banks
green
#3
fwy
tees
banks
green

Example #2: Same assumptions as #1, except actual pumping capacity is 350 gpm. Superintendent wants greens to run alone, and has maximized water use efficiency.



Acknowledgments

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