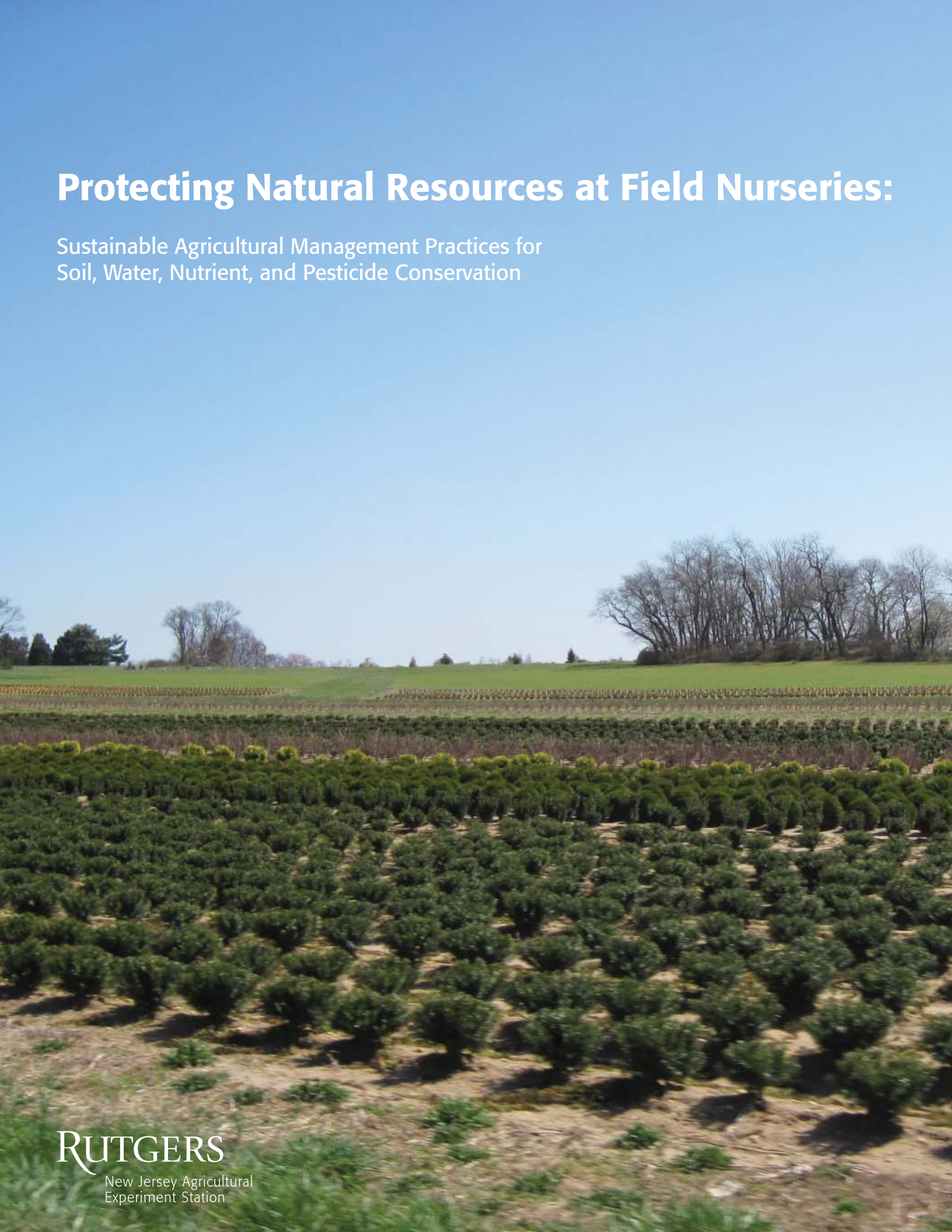
Protecting Natural Resources at Field Nurseries:

Sustainable Agricultural Management Practices for Soil, Water, Nutrient, and Pesticide Conservation



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Water Resources Program

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CONTENTS

01 INTRODUCTION

Nursery crop production is an important part of the agricultural industry in New Jersey. It provides the major portion of the income from agricultural crops grown in the state. The economic benefits support agriculture and local communities through their and their employee's expenditures for food, housing, entertainment, and personal and business equipment purchases. Through these inputs, they help to maintain the agricultural character of many areas in the state.

New Jersey is a densely populated state, and the demand on natural resources to support populated areas, businesses and agriculture can impact the natural integrity of state's varied ecosystems. Water use by homeowners, businesses and agricultural production may create a high demand on aquifers and other water resources. If not managed properly, they can inadvertently affect water quality in streams, rivers, and coastal bodies. Negative impacts can result from stormwater and other runoff that can carry eroded soil, fertilizers, or pesticides from households, businesses and agricultural uses.

It is important for all businesses to follow practices that optimize profitability while minimizing the chances for adverse environmental consequences. For nurseries, evaluating and optimizing production practices may help profitability by reducing costs for inputs such as water, fertilizer, and pesticides. In addition to being good stewards of the soil and water, a further benefit to nurseries may arise from the perception that those nurseries are "good neighbors" for their community.

This brochure is meant to offer field nurseries an outline of some practices they might consider integrating into their production systems.

Above, top: **An example of nursery field production**

Above, bottom: **Analyzers and controllers for irrigation water quality before and after treatment**

Above, top: **A biofilter at a nursery. Pollutants are removed from the water by the plants and microbes in the biofilter, as well as by physical settling out of sediment from the water.**

Above, bottom: **An impoundment area at a nursery holds water for use as irrigation**

WHAT'S A SAMP?

"SAMP" stands for "Sustainable Agricultural Management Practice".

- A "SAMP" can include almost any recommended practice that is done onsite. It can be as diverse as being part of crop production, erosion control, or vehicle maintenance.
- SAMP's are a set of practices that aim to optimize crop production while minimizing environmental impacts, costs, or chemical inputs.
- The term is preferred over "best management practice" because a given practice may not be "best" in all situations.

It's important to remember that a given SAMP may or may not be desirable for your operation or specific production practices. It's always important to consider how any change to current practices will impact changes in other practices, and how the new practices will affect product quality, production costs, and environmental impacts.

02 IRRIGATION MANAGEMENT

Water quality and water quantity

There are two factors you should assess when considering the source of irrigation water. They are the quantity of water needed and available, and the quality of that water for irrigation. In order to irrigate crops properly, irrigation events should be planned to deliver the optimum quantity of water with the best timing.

Irrigation water quantity:

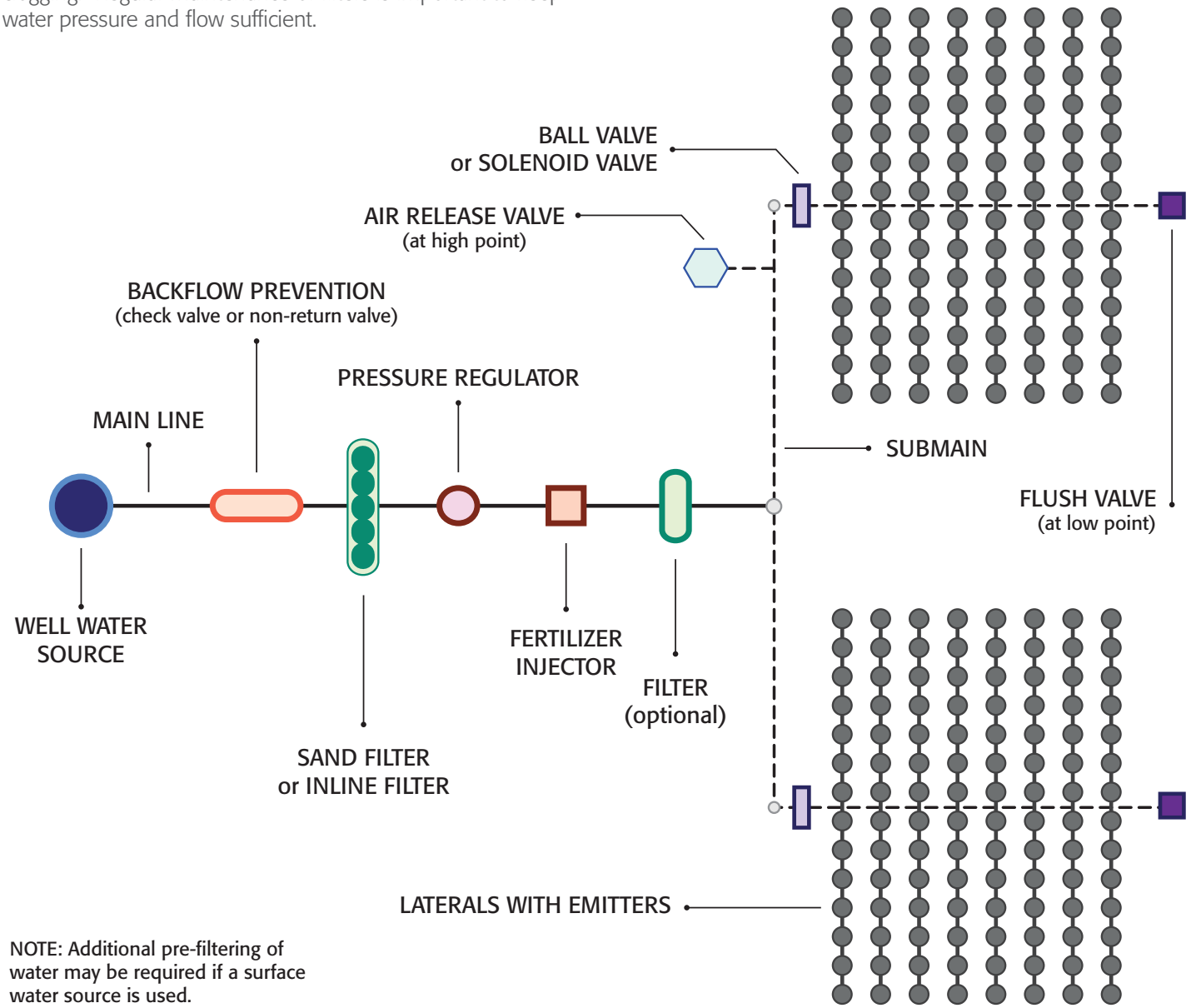
- Most nursery crops will need between one and two inches of water per week, depending on the crop, the season, and the weather.
- This amount can be reduced by the amount of rainfall.
- Rainfall varies. While New Jersey receives an average of about 48 inches of precipitation per year, the actual amount of rainfall in different locations throughout the state can vary widely in quantity and timing. Periods of low rainfall or summer droughts will necessitate ample irrigation for many crops no matter how much annual rainfall the location receives.

Irrigation water quality:

- Surface water can have particulate matter and algal content that may need to be filtered.
    - Ponds may also harbor plant pathogens.
- Water pH should be checked and adjusted as necessary.
    - Using water with a high pH or alkalinity may decrease the effectiveness of pesticides mixed with the water.
- Shallow wells can contain tannins that can discolor foliage.
- Well water may contain elevated levels of iron that can discolor foliage.
    - Excessive minerals such as iron or manganese or excessive hardness can cause clogging of drip emitters or leave spots on plant leaves.
- If your water source is located near tidal rivers or salt water, plan to test for sodium that can reduce growth or kill plants.
- Most deficiencies in irrigation water quality can be solved with some treatment of the water, but it may be costly.

DRIP IRRIGATION

Schematic representation of a micro-irrigation system. Always protect the water source with proper backflow prevention devices. Filters are important to prevent emitters from clogging. Regular maintenance of filters is important to keep water pressure and flow sufficient.



NOTE: Additional pre-filtering of water may be required if a surface water source is used.

Irrigation timing:

Soils

- Sandier soils and those soils lower in organic matter will hold less available water and will need to be irrigated more frequently.
- Silty and clayey soils may have standing water if over-irrigated but may not re-wet well if they get too dry.

Crops

- Plant species and varieties will vary in their tolerance for how dry soils can get without their showing water stress. Irrigation events should be timed to avoid stress and resultant yield reduction.
- Plant species and varieties have different water use needs. A further consideration is that plants can use only the water held in soils around their root zones. This means larger plants will generally be more tolerant to lower water conditions than are smaller plants.

Weather

- Plants require more water when it's hot, sunny, windy, and when the air is dry.

Don't get behind with watering. Most nurseries don't have the capacity to "catch up" if soils are too dry when they enter a drought.

Above, top: **Pot in pot production with micro-irrigation emitter**

Above, bottom: **UV water treatment system**

Above, top: **Chlorine gas treatment system, with cage for protection**

Above, bottom: **Chlorine gas injection system, detail**

Above, top: **Irrigation riser and filter for pot in pot production**

Above, bottom: **Sensors for irrigation water quality**

Above: **Irrigation with a center pivot system**

Irrigation systems:

Micro-irrigation

Refers to a low-volume, low-pressure system such as "drip" or "trickle" irrigation. Micro-irrigation is especially useful if the quantity of water available is limited and the quality is good or can be made good.

Micro-irrigation may be a good solution because:

- Less loss of water to evaporation and lower total water use.
- Wets only the root zone of the plant. More of the roots grow in the root ball area.
- Weeds are reduced by reducing wetting between crop plants. This translates into lower expenses for herbicides and labor.
- Field operations are less impacted by irrigation, since only a small surface area of soil is wetted during irrigation. Plants can be dug more quickly following irrigation.
- Fertilizer costs are reduced when using a micro-irrigation system.
- Disease problems may be decreased since leaves are not wetted by irrigation.
- Most well water is of acceptable quality for micro-irrigation.

Micro-irrigation may not be a good solution because:

- The costs of the initial investment for a micro-irrigation system may be high.
- The irrigation water will need to be of relatively good quality. Sand filtration may be needed that may increase costs. Particulate matter or minerals can clog emitters
- Maintenance of the system includes walking the lines to be sure there are no clogged emitters and checking for chewed or disconnected lines. With a filtration system, flushing or changing filters may also be required.
- If crops are changed often, the inconvenience of continually moving a micro-irrigation system may be considerable.

Overhead Irrigation

- Water cannons irrigate large areas quickly but have a tendency to compact soil and splash particulates.
- Center pivots and travelers provide gentler irrigation, reducing soil erosion and runoff.

NJDEP WATER USE CERTIFICATION

A permit to drill a well does not include the right to use water. Any agricultural use of water greater than 100,000 gallons per day or when pumping capacity exceeds 70 gallons per minute will require approval from NJDEP. Any diversion from a surface water body also needs approval. Additionally, you need to notify NJDEP if you replace a well, sell your property and want to transfer rights or seal wells, or add a new water source. Contact your county Rutgers Cooperative Extension agricultural agent for more information.

Right: **Water cannon irrigation**

Water treatment for pathogen control

Water from ponds or rivers may harbor pathogens that can cause diseases in crop plants. In these cases it may be necessary to treat the water to destroy these pathogens.

Treatment method options include:

- Chlorine
- Ultraviolet light (UV)
- Ozone (O_3)
- Bromine
- Copper is less common and is a known root inhibitor
- Each treatment method requires a proper rate and contact time to be effective in eliminating pathogens in water. While contaminants such as sediment or organic matter could interfere with any of these methods, UV is particularly ineffective if there are particulates in the water. Filtering out particulates before treatment with UV is advised.

Each treatment option requires assessing initial and continuing costs, potential safety issues, environmental impacts, and the possibility of having residual chemicals in water that may affect sensitive crops.

THINKING OF SIMPLE WAYS TO SAVE WATER:

Irrigation efficiency and uniformity

One important way to conserve water is using irrigation amounts and timings that are appropriate for your crop. Another way is make sure you're not wasting water by ensuring your irrigation is both efficient and uniform.

Irrigation efficiency: avoid leaks, overwatering, and irrigating non-cropped areas

Irrigation efficiency is simply a measure of how much of applied water is being used beneficially. Usually by "beneficial use", we mean water that is used to satisfy crop needs. Water that is not being used beneficially might include water that is sprayed onto a road or leaks from a pipe. Additionally, water that is being applied to crops but is applied in excess is not being used beneficially.

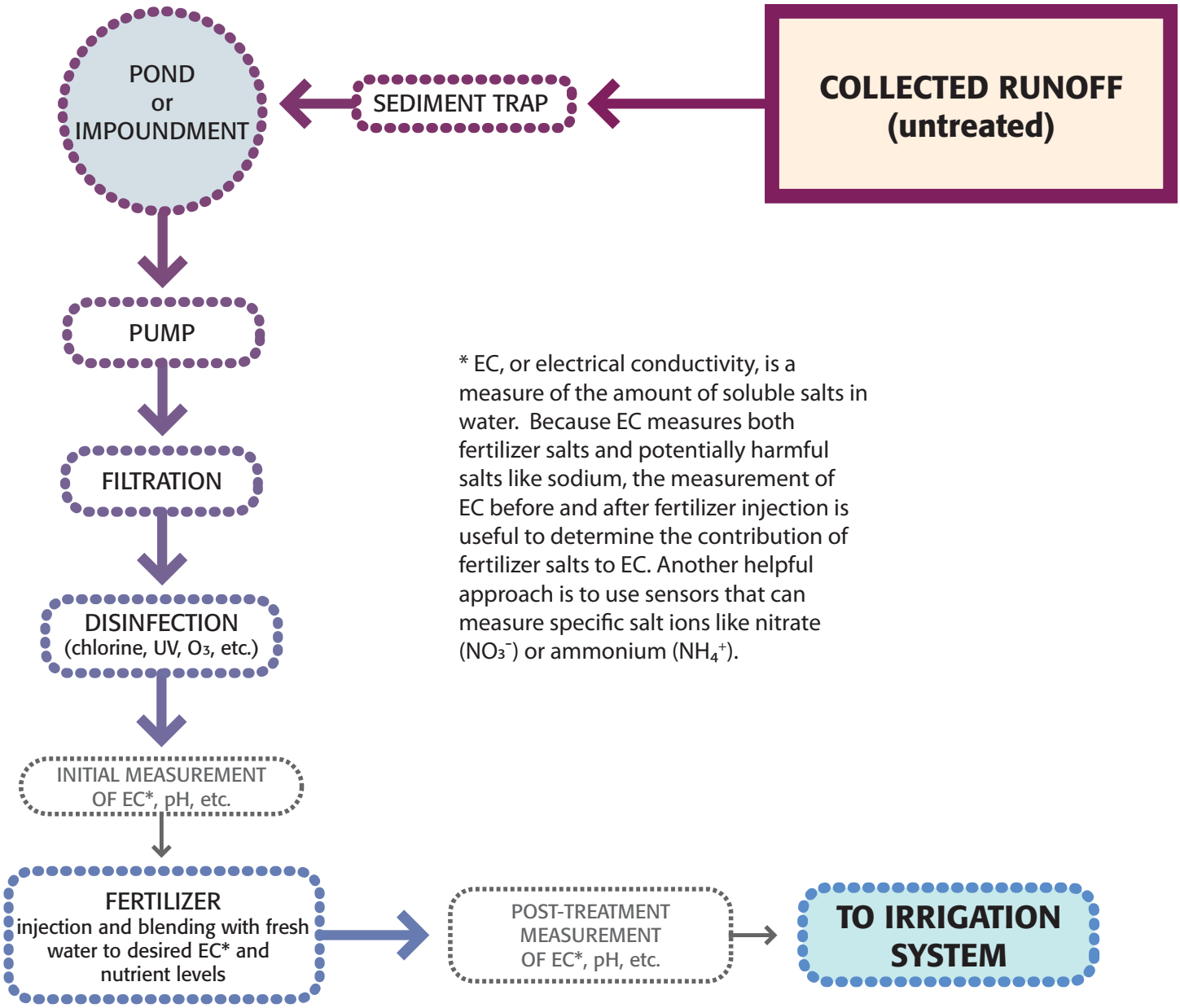
Irrigation uniformity: maintain your irrigation system so every plant gets the same amount of water

Irrigation uniformity is simply a measure of how uniform the irrigation system delivers water to each plant. When an irrigation system has low uniformity, inevitably some plants are being underwatered or overwatered.

To determine irrigation uniformity with overhead irrigation, catch cans can be set out around a zone to determine how much each collects during irrigation. For micro-irrigation systems, several emitters could be unplugged and allowed to fill catch cans.

RECYCLED WATER TREATMENT SYSTEM

Schematic representation of system to capture, treat, and reuse runoff. Note that filtration must be used before sanitation treatment to remove particulates that could interfere with the treatment. A sediment trap should be used to remove the bulk of the sediment in the runoff before storage in the main impoundment.



* EC, or electrical conductivity, is a measure of the amount of soluble salts in water. Because EC measures both fertilizer salts and potentially harmful salts like sodium, the measurement of EC before and after fertilizer injection is useful to determine the contribution of fertilizer salts to EC. Another helpful approach is to use sensors that can measure specific salt ions like nitrate (NO_3^-) or ammonium (NH_4^+).

03 NUTRIENT MANAGEMENT

Nutrient management is a balance between optimizing crop production and avoiding excess application of fertilizers. Excess nutrients can be lost to the environment and are then considered environmental pollutants. Applying excess fertilizer can also cause horticultural problems. For example, excess nitrogen in some crops can cause overly succulent plant tissues that may be more susceptible to disease, physical breakage and pest attacks.

Nutrients as environmental pollutants

- The two nutrients most of concern for potential losses to the environment are phosphorus (P) and nitrogen (N).
- Phosphorus attaches to exchange sites in the soil and moves offsite with eroded soil particles in runoff water. In fresh water ponds and lakes, elevated levels can cause eutrophication leading to algae growth that ultimately reduces oxygen and kills fish.
- Nitrogen in some forms can leach through soils into groundwater where it is considered a contaminant in drinking water. To meet the national standard, drinking water must contain less than 10 parts per million (ppm) of nitrate-nitrogen.
- Nitrogen is more of a concern for salty or brackish water. Estuaries including the Delaware, Barnegat and Raritan Bays are at risk where increased algal growth can lead to low oxygen levels that are dangerous to fish and other marine animals.

WHY IS SOIL ORGANIC MATTER SO IMPORTANT?

Soils in southern New Jersey often have soil organic matter levels lower than is desirable for crop growth. Low levels of organic matter in soil are a natural effect of having a relatively warm climate with relatively high annual precipitation. Additionally, tilling the soil promotes the rapid break down of soil organic matter.

Some benefits of organic matter in the soil:

- holds nutrients (increases the cation exchange capacity)
- improves soil structure, drainage, and aeration
- increases the water holding capacity of the soil, especially for light (sandy) soils
- promotes crop root growth
- allows for easier digging

Soil testing

Soil testing is the best tool available to determine nutrient management decisions and fertilizing practices.

- Soil testing should be conducted prior to each crop cycle and well before soil cultivation if possible.
- Soil tests should evaluate for pH, lime requirement, phosphorus (P), potassium (K), and micronutrients.
- Fertilizer recommendations based both on the soil test results and the need of your specific crops should be followed.
- Incorporate lime and major modifications of the phosphorus level well before the growing season starts
- Potassium and micronutrients should be incorporated into the soil during cultivation before planting.
- There is no established soil test for nitrogen (N) for most crops. Follow recent reliable recommendations for your crop. Applications should be split between the start of the cropping cycle and during the growing season.
- If you're unfamiliar with the properties of your soil, an analysis for soil texture and organic matter may help.

SOIL QUALITY

The term "soil quality" refers to a soil's ability to support plant growth, cycle nutrients, and percolate and hold water. Soil properties that promote soil productivity include:

- sufficient cation exchange capacity
- sufficient water holding capacity
- soils that are sufficiently well drained
- soil with good structure and tilth

TESTING COMPOSTS AND ORGANIC AMENDMENTS

Adding composts or other organic amendments is a useful way to increase soil organic matter.

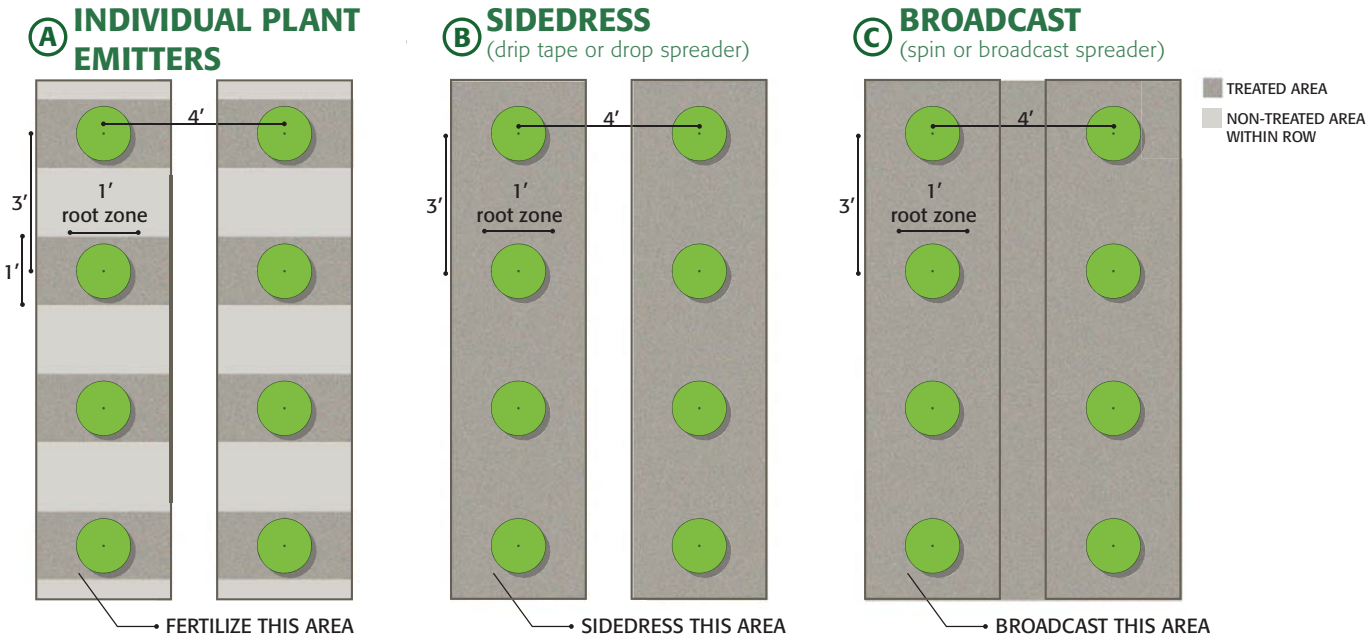
Certain popular amendments—such as mushroom soil—may have elevated levels of soluble salts. Other composts may have a poor balance of carbon to nitrogen or improper pH.

The Rutgers Soil Testing Laboratory can test the chemical properties of composts. A basic test evaluates soluble salts, pH, and nitrate-nitrogen. A more extensive test adds the carbon-to-nitrogen ratio, an index of compost maturity, and the concentrations of other nitrogen forms.

Left: There do not have to be deep gullies to prove there is an erosion problem. A good indicator is to check the color of water coming off fields during rainstorms. Watch also for dust during windy periods as an indicator of wind erosion. Because phosphorus often attaches to soil particles, soil erosion is a primary way phosphorus moves offsite.

Sustainable Agriculture Management Practices (SAMP's) for fertilizer application

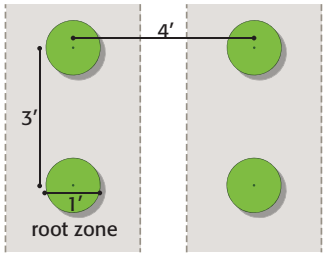
- Base fertilizer rates on soil tests and crop recommendations.
- Split nitrogen applications to use smaller amounts more frequently. This promotes an efficient uptake of fertilizer and limits losses to the environment.
- Sidedress fertilizer instead of broadcast. This puts fertilizer closer to the root zone. When sidedressing, reduce the amount of fertilizer applied down to the actual area where fertilizer is being applied, or use a fertilizer rate based on a per-plant basis.
- Let plant needs guide fertilizer rates. Slower-growing cultivars and species generally need less fertilizer than faster growing plants.
- Consider controlled-release fertilizers.
- Don't apply phosphorus fertilizer where need is not indicated by a soil test unless there is a specific crop need. (This may occur with cool soil temperatures.)
- Consider fertigation, which is injecting fertilizers into the irrigation water. This allows very efficient fertilizer use, since plants are being "spoon fed" with a small amount of fertilizer at a time. A backflow prevention system is required for fertigation. Be sure to avoid creating irrigation runoff when using fertigation.



FERTILIZATION APPLICATION EFFICIENCY

Fertilizing only the area in which roots grow effectively reduces the amount of fertilizer used. The greatest reduction can be achieved by using individual emitters in a microirrigation system because of precise placement and the tendency to confine the root system (A). Sidedressing fertilizers also conserve fertilizer (B). Sidedressing can be accomplished with micro-irrigation or drop spreaders. In contrast, broadcast fertilization is a more traditional method of applying fertilizer where the whole area under cultivation is fertilized (C).

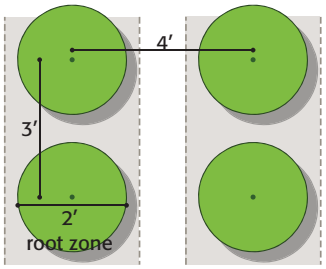
YEAR 1



1-FT × 1-FT ROOT ZONE AREA

FERTILIZER METHOD	CALCULATION (amount of land fertilized)	TOTAL N USED (per acre of land)
Broadcast	1 acre fertilized at 100 pounds/acre	100 pounds
Sidedress	50 rows × 216 feet/row × 1-foot wide root zone = 10,800 sq-ft.	24.8 pounds
Individual plant	50 rows × 72 plants/row × 1×1-square-foot/plant = 3,600 sq-ft.	8.25 pounds

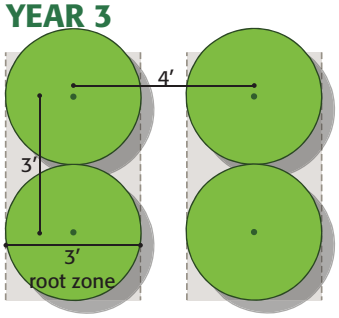
YEAR 2



2-FT × 2-FT ROOT ZONE AREA

FERTILIZER METHOD	CALCULATION (amount of land fertilized)	TOTAL N USED (per acre of land)
Broadcast	1 acre fertilized at 100 pounds/acre	100 pounds
Sidedress	50 rows × 216 feet/row × 2-foot wide root zone = 21,600 sq-ft.	49.6 pounds
Individual plant	50 rows × 72 plants/row × 2×2-square-foot/plant = 14,400 sq-ft.	33.4 pounds

YEAR 3



3-FT × 3-FT ROOT ZONE AREA

FERTILIZER METHOD	CALCULATION (amount of land fertilized)	TOTAL N USED (per acre of land)
Broadcast	1 acre fertilized at 100 pounds/acre	100 pounds
Sidedress	50 rows × 216 feet/row × 3-foot wide root zone = 32,400 sq-ft.	74.4 pounds
Individual plant	50 rows x 72 plants/row × 3×3-square-foot/plant = 32,400 sq-ft.	74.4 pounds

SPACING OF PLANTS CAN AFFECT THE EFFICIENCY OF FERTILIZER USE

Option 1: Space young plants closely together, then transplant to wider spacing when plants mature. In this case, efficient nutrient use can be achieved by broadcasting fertilizer to both young plants and mature plants; however, this option requires labor-intensive transplanting of stock.

Option 2: Establish young plants at the final spacing desired for mature plants. This option avoids the need to transplant stock, but may require switching fertilizer application methods to achieve the most efficient nutrient use. For example, young plants could receive their fertilizer with individual drip emitters, but the stand of mature plants could be fertilized with broadcasting or sidedressing.

ASSUMPTIONS USED IN THIS EXAMPLE:

Hypothetical recommended rate = 100 pounds per acre N

For this example, a 3 foot x 4 foot plant spacing is assumed.

The root zone area is assumed to be 1 foot x 1 foot initially.

The total plant population per planted acre =3,600

The block has 50 rows of 72 plants each.

04 PESTICIDE MANAGEMENT

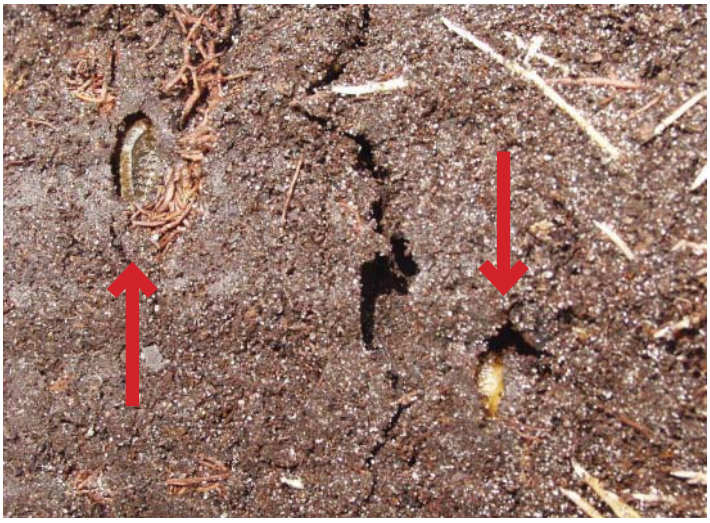
What is Integrated Pest Management (IPM)?

Integrated pest management is a system where pest populations and problems are identified early and treated at a threshold by a method that will effectively control the problem. An effective program will maximize crop quality and minimize impacts to the environment. Some key points to implementing an IPM program are:

- Scouting for pests by trained personnel. This can include using direct observation, sticky cards, or pheromone traps.
- Correctly identifying potential pests.
- Considering non-chemical methods of control.
- Applying pesticides only when determined by an actual level of pest presence or the likelihood of an infestation based on prior experiences (for example an insect outbreak that has occurred at this site before and can be predicted by a degree-day model).
- Avoiding treatments that can have a negative impact on beneficial organisms.
- Choosing and applying pesticides to be effective while minimizing environmental impacts.
- Good record keeping.

Below, left: **A beneficial organism, the praying mantis**

Below, right: **Oriental beetle pupae**



Non-chemical control methods

Pesticide use and the associated costs of product and labor can often be decreased if growers utilize non-chemical control methods for weeds, insects, and diseases. Often an understanding of the life cycle of the pest is needed to choose appropriate methods. Growers should also be cautioned that some cases might require pesticide use, for example the legal requirements of shipping nursery stock out of state.

- Plants under stress typically are more susceptible to pest problems.
    - Maintain good plant nutrition
    - Maintain optimal soil moisture levels
    - Provide for good air drainage of crop beds
    - Avoid prolonged leaf wetness following irrigation cycles
- Consider improving habitat for beneficial insects.
- Introduce commercially available beneficial insects when appropriate for control of identified pest problems.
- Consider using other commercially available biological methods such as *Bacillus thuringiensis* (Bt) to control labelled caterpillars or grubs, or applying beneficial nematodes.
- Consider mechanical control methods.
- Use proper sanitation:
    - Remove pest-harboring plant debris
    - Inspect or quarantine new plants
    - Remove weed debris that harbor seeds or spreading vegetative parts

A NOTE ON PERSONAL PROTECTION FROM PESTICIDE EXPOSURE

The risk of harm from a pesticide is a combination of the toxicity of the pesticide and the exposure to the pesticide.

Risk = toxicity × exposure

- Greater exposure to a lower toxicity product can be more serious than less exposure to a more toxic product.
- Remember that a pesticide can enter the body through the skin, through the air you breathe as well as through ingestion (eating or drinking).
- Always use recommended personal protective equipment and follow recommended personal protective procedures.




Know your weed, know your herbicide

It's important to identify the weed so the appropriate means of control can be chosen. If a herbicide is needed, it's necessary to understand the categories of herbicides and when they might be useful.

Selective and non-selective herbicides

- Selective herbicides are effective against only a certain group of plants (such as grasses) or a specific list of weeds.
- Non-selective herbicides (such as glyphosate) are effective against a broad range of plants, including desirable plant material. Some plants and weeds may exhibit resistance and results in lower control levels than expected.

Contact and systemic herbicides

- Because contact herbicides (such as diquat) will kill only the parts of the plant that they come in contact with, they are usually effective only against young plants and annuals. Good spray coverage is essential.
- Systemic herbicides are taken up by plants and translocated throughout the plant parts, killing the entire plant. Systemic herbicides are more effective if applied to actively growing weeds, though certain types of plants will be more susceptible at different times of the year.

Pre-emergent herbicides

- Pre-emergent herbicides stop weed seeds from germinating. Because they form a chemical barrier on the soil, subsequent soil cultivation will break the barrier and cause the herbicide to lose effectiveness.

Annual and perennial weeds

- Perennial weeds do not die in the winter so control necessitates destroying the entire plant including the roots, usually by the application of a systemic herbicide. In some cases repeated cultivation also works. With rhizomatous weeds, be cautious with cultivation which could spread the weed further.
- Annual weeds die at the end of each season and rely on their seeds germinating for the next generation. The best control is from preventing seed production. Depending on the crop, methods of control include mowing and/or use of a contact herbicide, use of a pre-emergent herbicide to prevent seeds germination, or killing the entire plant with a systemic herbicide.

Common weeds

from left to right: **Bindweed (*Convolvulus arvensis L.*), Mugwort (*Artemisia vulgaris*), Wild garlic (*Allium vineale*), Japanese stiltgrass (*Microstegium vimineum*), Quackgrass (*Elytrigia repens*), Prostrate knotweed (*Polygonum aviculare L.*), Bull thistle (*Cirsium vulgare*)**

Photo credits: Carrie Mansue, Rutgers University

Controlling perennial weeds

Perennial weeds can be particularly difficult to control once they become well established. There may be limited options for chemical control methods for some perennial weeds. Some methods for helping control them include:

- Begin planning for weed control before planting the crop. Scout the production area for difficult weeds like mugwort, multiflora rose, Canada thistle, field bindweed and rhizomatous grasses.
- Plan to use chemical controls that will kill the plants for those difficult to control weeds identified.
- Use cover crops and fallow periods to reduce weed pressure.
- When feasible, grow different crop species in separate blocks to maximize chemical control options.

PESTICIDE USE CERTIFICATION PROGRAM

In New Jersey, agricultural businesses that apply general or restricted use pesticides must have one employee that possesses a New Jersey pesticide applicators license, and follow all applicable rules and regulations. If the business is a farm and applies pesticides to their own or rented property, the applicator should have or work under the direct supervision of a person who has a Private Applicator License. Any business that applies pesticides to another person's property, such as landscaper or tree service, should have at least one applicator licensed with a Commercial Pesticide License.

- To become licensed, farmers must pass the NJDEP Private Applicator Exam. Licenses are good for five years (NOTE: the process is different for a commercial license). During that 5-year period, applicators must receive 8 credits of core classes and 16 credits of category-specific classes.
- Farm employees can apply pesticides under the supervision of a licensed applicator if they have been trained via an EPA-approved training program as a "pesticide handler." Training must be done annually if no verification card is distributed, and a roster of trained employees must be maintained. Verification card can be obtained from NJDEP Pesticide Control Program. Receipt of the cards reduces training to once every five years.
- All EPA and NJDEP worker protection rules and regulations should be followed. Employees need to receive training on the first day of employment or before working in a field treated with pesticides within the past 30 days.
- An inventory of pesticides must be maintained and must be submitted to the local fire department annually.
- Additionally, use report must be submitted to the NJDEP Pesticide Control Program once every three years.
- More information on licensing can be obtained from the Rutgers Cooperative Extension Pest Management Office, New Jersey Pesticide Applicator Training, http://pestmanagement.rutgers.edu/PAT/index.htm, or NJDEP Compliance and Enforcement, NJ Pesticide Control Regulations, http://www.nj.gov/dep/enforcement/pcp/pcp-regs.htm.

Sustainable Agricultural Management Practices (SAMP's) for pesticide application

- Following recommended SAMP's helps ensure effective control and limits environmental impact.
- Be sure you have correctly identified your crop and the target pest.
- Read and follow the label. Following the pesticide label is required by law and is usually the best method to ensure pesticide efficacy, protect workers, and prevent environmental impacts.
    - Follow recommended rates.
    - Do not use less than the recommended rates since it may lead to pest resistance.
- Mix only as much product as will be needed, and use all that is mixed.
- Calibrate sprayers and spreaders.
- Rotate between classes of pesticides to reduce pest resistance issues.
- Use enhanced application techniques when available: spraying isolated hot spots, using banded applications, utilizing staggered applications.
- Avoid spraying in wind or before significant rain.
- Always use backflow prevention devices and protect well-heads and waterbodies.

NARROW-SPECTRUM AND SHORTER-RESIDUAL PESTICIDES

In response to environmental concerns, there has been a movement away from broad-spectrum pesticides with longer residuals. The broad-spectrum pesticides were very useful because they controlled a broad range of pests and continued to be effective for relatively long time periods. The strengths of broad spectrum, long-term control also became their weaknesses when they entered the environment. Ultimately, they tended to be toxic to a wide range of organisms for a relatively extended period of time.

In response to those concerns, narrow-spectrum pesticides with shorter residuals were developed. The newer pesticides tend to have a more defined spectrum of pests controlled, lower mammalian (human) toxicity and shorter residual effectiveness. Depending on the pesticide, entry into the environment can still have a negative impact although it is usually more focused (such as toxicity to aquatic insects and fish.)

Use of pesticides with a narrower spectrum and a shorter residual is considered a SAMP. To yield effective control, it tends to require the grower have more knowledge about the target pests, timing of applications, and possibly the availability of effective non-chemical methods.

PESTICIDE LEACHING, RUNOFF, AND TOXICITY

Leaching potential

Pesticides which are likely to be able to leach into the soil are those which have a high solubility in water and a low tendency to adsorb to soil particles. Pesticides of most concern are certain herbicides. On the other hand, pesticides which adsorb to soil particles or organic matter in the soil generally stay near the surface of the soil and do not leach to groundwater.

Runoff potential

The most important factor in determining how likely a pesticide will move with runoff is how persistent the pesticide is in the environment. Products which last longer will be more likely to move offsite with stormwater, whether the chemical dissolves in water or if the chemical adsorbs to soil particles. Concern about pesticide runoff is greater when runoff amounts are greater or if there is soil erosion occurring onsite.
Many pesticides tend to stick to eroded soil particles or organic matter. This allows them to move with runoff attached to particulates. Determine if there is significant movement of sediment or other debris off your property. Install vegetated areas or structures to capture sediment and retain it onsite.

Toxicity

The final factor in determining the risk of a pesticide to water resources is the toxicity of the product. Even if the risk of leaching or runoff is relatively low, toxic or persistent products could be problems if they make their way into waterbodies. On the other hand, a pesticide which is non-toxic, short-lived, and has a low tendency to move offsite represents little risk.

Information on individual pesticides

Check at the "PesticideWise" website to help determine the solubility, leaching potential, runoff potential, and toxicity of pesticides being used. (http://www.pw.ucr.edu/).

Pesticide losses to the environment

When planning pesticide applications, growers should remember that pesticides can be lost to the environment during mixing, transport, and application. Always ensure that losses of pesticides to the environment are minimized. The ways in which pesticides can be lost to the environment include:

Method of pesticide movement	Definition	How to prevent movement offsite
Drift	The movement of product by wind or gentle air currents	It is against the law to allow a pesticide to move off-target by drift. Avoid spraying in windy conditions.
Runoff	The movement of product with water running off the land surface	Avoid applications before significant rains. Install vegetated areas or structures to treat runoff.
Leaching	The movement of product downward through the soil with the water	Only some pesticides can leach significantly through the soil. Be cautious when applying on sandy, low-organic-matter soils or when there is a shallow depth to water table (< 20 ft.). Choose pesticides taking into consideration the need for low leaching potential. Avoid applications before significant rain or irrigations.

05 WHOLE FARM MANAGEMENT

Sustainable conservation practices for production and non-production areas

Major rain events can be expected to cause runoff from production areas even with the best management practices. While major rain events may be beyond one's control, effective practices are available that will provide nearly full control of runoff during irrigation and normal rain events. To reduce the impact of agricultural operations, it is important to implement conservation practices that minimize the effect of runoff into local waterways.

Soils in southern New Jersey are typically quite low in organic matter content. Organic matter has a high cation exchange capacity that helps maintain high nutrient content and reduces the potential for leaching of nutrients. It is therefore important to increase organic matter levels in soils with a low content. Water and wind can cause soil erosion from unprotected agricultural land. Use of cover crops can both help increase organic matter and reduce erosion during production and fallow periods. Some recommended practices include:

Agricultural practices that will enhance environmental quality

- Vegetated buffers between production areas and water bodies
- Stormwater ponds and constructed wetlands to collect and treat runoff
- Grassed waterways and swales
- Gravel, clamshells, or vegetation to protect roads from erosion
- Mulch, gravel, vegetation, or rock protection on slopes prone to erosion
- Contour planting

Below, left: **A driveway area protected from erosion with a covering of clam shells.**

Below, center: **Contour planting with grass stabilization strips.**

Below, right: **A bank of a biofilter is stabilized with erosion control fabric. Grasses are planted along the bank to stabilize the soil and aid in nutrient removal from the water.**

Above, left: For seasonal flow, a grassed waterway is an effective practice to move water offsite. If the waterway is consistently wet, it may be necessary to stabilize it with landscape fabric and stone.

Above, right: Cover crops in the foreground protect fallow ground from erosion.

Management Options

Maintaining effective grassed alleyways

- A dense grass or vegetative stand is effective at slowing water, capturing sediment, and immobilizing some nutrients and other potential pollutants.
- Grassed alleys also allow better access for equipment when soils are moist than do bare soils.
- To avoid weed problems, grasses should be mowed regularly to prevent seeding.
- To enhance nutrient uptake by nursery crops, rows should be kept clean and weed free using herbicides or other effective methods.
- Turf-type tall fescue is a non-native grass that is well suited for use in erosion and runoff control applications in nurseries. It is well adapted to for growth in New Jersey, is relatively low growing, dense, and somewhat drought tolerant. It may not do well in soils that are consistently wet.

Soil retention and soil building

- Use a vegetative cover between crop rows to stabilize soil, prevent erosion, slow runoff and retain sediments.
    - Cover crops need to be planted early enough in the fall to ensure good growth and adequate coverage but late enough to avoid plants going to seed and becoming a weed problem.
    - Certain warm season grasses such as the sorgum-sudan hybrids are not cold hardy and will die when temperatures drop below the freezing point. In the event that frosts arrive too late, it will be necessary to mow the crop when the first seed heads start forming.
- Control irrigation to avoid producing runoff, soil compaction, and crusting soils.
    - Use micro- or trickle irrigation
    - Use gentle overhead systems (center pivots, travelers)

- Add organic matter to soils during fallow periods. Consider composts, crop residues, green manure, and animal wastes. Determine the strengths and limitations of each organic matter source and choose ones that will fit best into the nursery operation.
    - Composts are naturally variable. While growers can control the quality of composts that are prepared onsite, there are DEP rules that regulate its production. Otherwise, growers will need to rely on the preparer of imported composts to ensure quality.
        - Crop residues have the potential to harbor diseases and insects unless composted.
    - Green manures and cover crops must not be allowed to go to seed or they can become a weed problem.
    - Animal wastes generally have weed seed problems.

Left: A pesticide fill area. The impervious pad has a curb to contain any spills.

Pesticide and fertilizer storage, mixing, and staging

- Keep all fertilizer and pesticide mixing operations separate and at least 100 feet away from wellheads to avoid contamination.
- Label pesticide spray tanks to avoid herbicide contaminated sprayers from being used for fungicides or insecticides.
- Lock all spray tanks to avoid the possibility of outside contamination.
- Storage facilities
    - All storage and mixing facilities should be locked, have an impermeable floor and be covered by a roof so that all products are protected from wind and rain.
    - It is required that pesticides are kept in original containers with intact labels.
    - Liquids should have an impermeable secondary storage in case the primary containment leaks. The secondary container must be able to contain at least the volume of liquid in the primary container.
    - Use appropriate ventilation and warning signs
    - Report chemical inventories to the fire department and other appropriate agencies.
    - Keep spill kits available, and train employees in what to do in case of spills.
    - Dispose of pesticide containers properly
- Dispose of rinse water from pesticide equipment properly.
- When planning a facility, consider a design that will provide for a system that can store rinse water for use in a subsequent application.

SAMP's for production and non-production areas

- For nursery crops with wide spacing, establish grass crops between rows or beds to stabilize soils .
- When cropping on sloped land
    - Plant on the contour
    - Create grass stabilized swales to interrupt surface water flow
    - Plan to stabilize steeper hillsides, especially near bodies of water
- Use cover crops whenever land is fallow
- Choose an irrigation system that minimizes runoff
- Keep fertilizers and pesticides from being washed or spilled into the environment
    - Build a secure and properly designed pesticide storage facility
    - Precisely mix pesticides so ALL of it is used up and storage is avoided
    - Secure with locks all storage facilities and spray tanks

Above, top: **A pesticide storage area. The room is protected from wind and rain and has an impervious floor to prevent contamination. Furthermore, the room is secured to prevent theft.**

SOME COVER CROPS APPROPRIATE FOR USE IN NEW JERSEY NURSERIES

SPECIES	SEEDING RATE	WEIGHT (pounds/bushel)	PLANTING DATE
Barley	2.0 bu/A	48	August - October
Rye (annual)	1.5 bu/A	56	August - October
Ryegrass (annual)	2.0 bu/A	24	August - October
Oats	1.5 bu/A	32	August - October
Buckwheat	1.5 bu/A	45	August - October
Wheat	25.0 lb/A	60	August - October
Crimson Clover	20.0 lb/A	60	August - October
Sorghum-Sudan Hybrids	25.0 lb/A	50	April - May

Right: An impoundment is used to capture any tailwater for reuse as irrigation, reducing the amount of withdrawls from groundwater.

Planning for drought

With New Jersey's variable weather, there are periods of below normal rainfall when drought conditions can occur. Droughts can be dangerous for commercial nursery operations particularly when they combine with hot, dry, and/or windy weather that increases plant water needs. Furthermore, there is increased pressure on water sources during these periods when the water needs of non-agricultural uses increase as well. It is important for nurseries to have prepared plans for drought conditions since the perception of excessive water use can generate negative public and political pressures.

Motivations for adopting preparations for drought include:

- Achieving a more drought-resistant operation
- Conserving water
- Promoting the nursery industry as a good neighbor that conserves environmental resources
- Showing that the industry uses water as efficiently as possible during times when other users are being asked to conserve

Drought preparedness for field nurseries

Soil conditioning

- If a sub-surface hard pan exists in the soil, break it by sub-soiling or using a mechanical spader. This produces a deeper effective soil depth, allowing for deeper root penetration and more water storage by the soil.
- Increase or maintain soil organic matter levels. This produces a soil with better structure and better water holding capacity.

Optimize irrigation scheduling

- Base irrigation frequency on plant needs and weather. Some techniques include:
    - Use of soil moisture sensors and automatic irrigation systems
    - Use of rain gauges or local rainfall reports
    - Determining daily evapotranspiration by using onsite weather stations, evaporative pans, or local sources such as the data reported at http://www.unitedwater.com/et-lawn-water.aspx
    - Visual and tactile inspection of soil for moisture content
- Always fine tune and confirm application schedule to production needs and water conservation goals.

Optimize irrigation application

- Avoid irrigating during midday heat to lessen evaporative losses.
- Match irrigation rate with soil infiltration capacity to avoid generating runoff.
- Inspect irrigation equipment for leaks, worn nozzles, uneven irrigation, or application to non-cropped areas.
- Group crops by water needs.
- Avoid irrigation water falling on public highways.
- When possible, restrict overhead irrigation during the morning and evening commuting periods when water use is most visible to the public.

Improve irrigation system and efficiency

- Consider trickle or other low volume irrigation systems
- Consider reusing tailwater that has been captured by an impoundment
- Use low pressure heads that produce large droplets
- Consider the use of shade cloth for plant holding areas to reduce evaporation and root temperatures

For more information:

Johnson, James. 2002. *New Jersey Nursery Drought Management Plan*. New Brunswick, NJ: Rutgers Cooperative Extension. http://njaes.rutgers.edu/drought/pdfs/nursery-droughtmgt.pdf.

New Jersey Agricultural Experiment Station. 2010. "Drought Resources." http://njaes.rutgers.edu/drought/.

Impervious Cover and Nursery Runoff

Agricultural land can contribute to the impairment of local waterbodies when runoff water leaves the property. One factor that affects how much local waterways are impaired by surrounding land is the amount of impervious cover there is on those lands.

Impervious cover is defined as any land cover that does not allow precipitation to infiltrate into the ground. In a developed residential area, impervious cover includes roofs, driveways, and streets. On farms, impervious cover can include buildings, roadways and parking lots, covered greenhouses, and container production houses that have polyethylene floor covers. When rain falls on these surfaces, there is the potential to pick up any pollutants and move them to nearby waterways. There, the runoff contributes pollutants and deposits sediment. High flows from runoff can scour a waterway and cause flooding. As the percentage of impervious cover increases, the likelihood of surface water impairment increases.

Connected Impervious Cover vs. Disconnected Impervious Cover

It is important to understand that the real effect of impervious surfaces on a watershed may depend *less upon the total amount of impervious cover and more on how the individual impervious areas are connected.*

Imagine a 3-acre area with 1 acre of impervious cover where the net runoff flows directly into a ditch or stormwater conveyance. In the first scenario (A), all the runoff from the impervious area flows directly to the ditch, as does any runoff from the pervious area. In this case, an example 1-¼-inch rainstorm would produce 28,500 gallons of runoff.

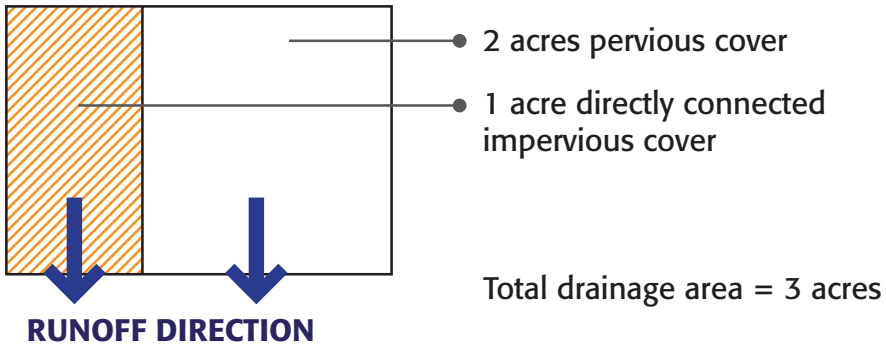
But imagine a second scenario (B), in which the runoff from the impervious area instead flows over the pervious area before reaching the ditch. In this case, the same 1-¼-inch rainstorm would produce only 4,360 gallons of runoff. And the pervious area would be even more effective for less intense storms and areas with higher infiltration capacities.

Below, left: **Bio-retention area for intercepting and treating nursery runoff.**

Below, right: **Wetland for intercepting and treating nursery runoff.**

SCENARIO A

Example of runoff in a case of connected impervious cover (NJDEP 2004).

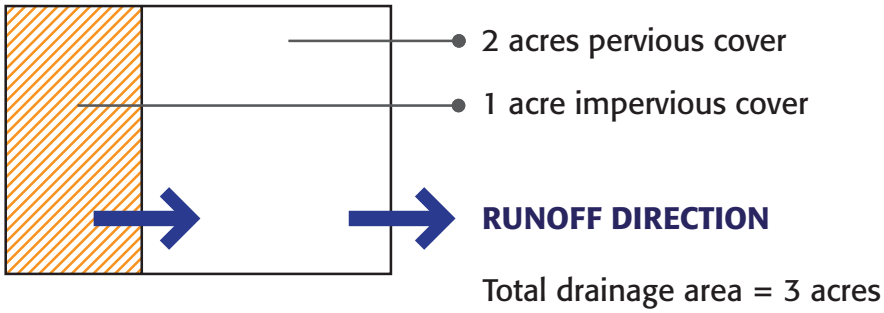


For 1.25 inch storm, runoff = 28,500 gallons

SCENARIO B

Example of runoff in a case of disconnected impervious cover (NJDEP 2004)

In these examples, the impervious area is assumed to be almost entirely impervious, while the pervious area is assumed to be partially pervious, which is a reasonable assumption for some agricultural lands. Better runoff mitigation would be observed in the examples if the land were assumed to be forest, meadows, or turf areas with high runoff interception and high infiltration capacities.



For 1.25 inch storm, runoff = 4,360 gallons

Effective Impervious Area

From these scenarios, the idea of *effective impervious cover* is developed. If a series of greenhouses are connected in a way that all the runoff flows directly to the stormwater ditch, then the effective impervious area is the same as the total area of the greenhouses. But if the runoff from each individual greenhouse flows to a pervious area (such as a grassed or wooded area), then the effective impervious area is greatly decreased. Likewise, runoff from roads and buildings can be diverted to pervious areas or detained in stormwater management systems such as constructed wetlands, bio-retention basins, infiltration ditches, swales, pervious pavement, and detention impoundments. By diverting stormwater runoff from impervious surfaces to pervious areas and allowing it to infiltrate, or by diverting it to stormwater management systems, stormwater impacts will be reduced and groundwater recharge will be increased.

Reference:

NJDEP (New Jersey Department of Environmental Protection). 2004. "Computing Stormwater Runoff Rates and Volumes" in New Jersey Stormwater Best Management Practices Manual. http://www.state.nj.us/dep/stormwater/bmp_manual2.htm.

06 REFERENCES and FURTHER READING

Complete Rutgers Cooperative Extension Field Nursery SAMP Reference

- Soil, Water, Nutrient and Pesticide Agricultural Management Practices for Field Nurseries in the Upper Cohansey River Watershed.
  http://njaes.rutgers.edu/nursery

Other AMP Guides and Factsheets

AMP Guides

- Southern Nursery Association: Best Management Practices Guide 2.0.
  Order through http://www.sna.org/forms/SNAProductOrderForm.pdf
- University of California: "Management Practices to Protect Water Quality: A Manual for Greenhouses and Nurseries". http://ceventura.ucdavis.edu/files/32117.pdf
- Oklahoma State: "Water Quality Handbook for Nurseries".
  http://osuextra.okstate.edu/pdfs/e-951.pdf

Rutgers Factsheets and Websites

- Pest Control Recommendations for Shade Trees and Commercial Nursery Crops. By A. B. Gould, S. Hart and J. Lashomb. NJAES pub. #E036. http://njaes.rutgers.edu/pubs/publication.asp?pid=e036
- Evaluating Water Quality for Ornamental Plant Production, FS893. Raul Cabrera. http://njaes.rutgers.edu/pubs/publication.asp?pid=FS893
- Rutgers Nursery Integrated Pest Management (IPM) http://www.pestmanagement.rutgers.edu/IPM/nursery/

Standards for Nursery Products and State Rules

- The American Standards for Nursery Stock. ANSI 60.1. American Association of Nurserymen. 1250 I Street N.W. Suite 500, Washington D.C. 20005.
  http://www.jerseygrown.nj.gov/jgstandards.pdf
- New Jersey Department of Environmental Protection rules and regulations can be found on the Internet at:
  http://www.nj.gov/dep/enforcement/pcp/pcp-regs.htm

Information on Soil and Soil Quality

- Archived historical soil survey publications for New Jersey counties.
  http://soils.usda.gov/survey/online_surveys/new_jersey/
- Soil quality information is available from the Natural Resources Conservation Service online.
  http://soils.usda.gov/sqi/
- Web Soil Survey website.
  http://soils.usda.gov/survey/

Information on Water Quality Risks for Specific Pesticides

- PesticideWise. Information on leaching risk, runoff risk, and toxicity of specific pesticides.
  http://www.pw.ucr.edu/

Information on New Jersey Pesticide Use Certification

- Rutgers Cooperative Extension Pest Management Office, New Jersey Pesticide Applicator Training.
  http://pestmanagement.rutgers.edu/PAT/index.htm
- NJDEP Compliance and Enforcement, NJ Pesticide Control Regulations.
  http://www.nj.gov/dep/enforcement/pcp/pcp-regs.htm

http://njaes.rutgers.edu/nursery

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