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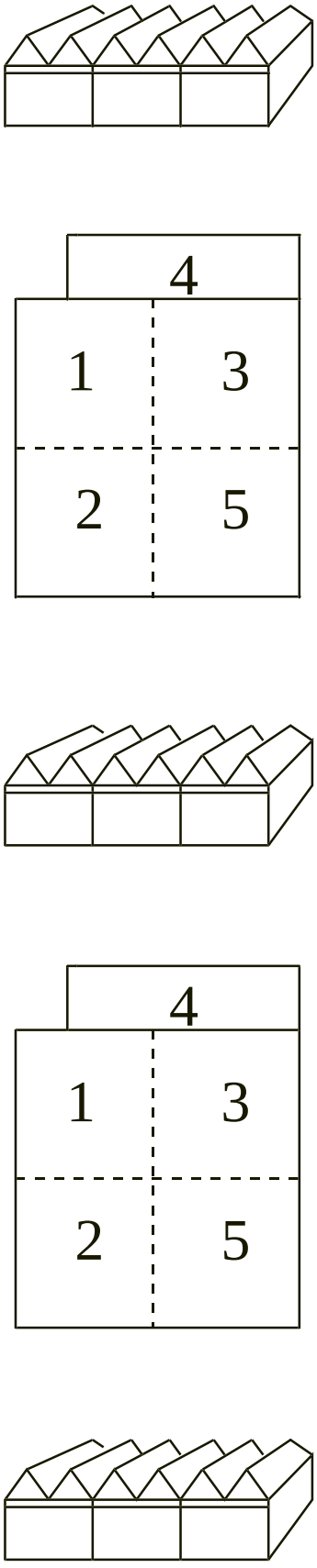
NEW JERSEY AGRICULTURAL EXPERIMENT STATION
E221

Creating a Master Plan for Greenhouse Operations



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"Don't sew a shirt to a button." This is a statement my predecessor, W.C. Krueger, always said to someone contemplating growth and expansion in an operation. The older I grow the more I realize that this is very sage advice. People who are the most unhappy after a change are those who altered existing facilities, tried to make them work, and ended up spending as much money as if they had built new, without the benefit of a new facility.

Changes in the greenhouse industry during the past 10–15 years have made greenhouse facilities much more expensive. This makes it necessary to plan the overall design of the facilities with extreme care in order to avoid costly retrofits at a later stage A comprehensive master plan is required which reflects how the owner/operator intends the completed facility to look. A key component of the plan is the integration of all the systems and buildings comprising the entire greenhouse system.

For financial reasons, it is usually not possible to include all the desired systems and installations in the initial design of the facility. However, the overall plan should provide that these systems and installations are included and that they can be added at a later date without trouble or high costs.

It is always a good idea to establish priorities and not to compromise in the plan. The priorities and systems selected and included in the first installation should always be options that provide the greatest returns. The 'luxury items' can be added at a later date.

There are many items to consider in formulating a facilities master plan, because it is only part of an organizational master plan. It is always easier to add a greenhouse than to develop an overall goal and a plan to achieve it. Both technical and business management skills are required in any organization. Excellence in only one area cannot guarantee business and operational success.

The Business Plan

A business plan is an important part of an overall master plan. Expansion or improvement of facilities always implies added costs and the expansion must be considered in line of the profitability and overall plan of the organization.

Brumfield suggests the following Strategic Planning Process which includes the questions, What? Why? and How? See Figure 1. Milligan suggests several components to a successful business plan. See Figure 2.

Greenhouse Design

There are many items to consider when contemplating the location and design of a greenhouse. These include the following:

- Site selection
- Orientation for optimum light utilization
- Strength to handle environmental conditions of wind and snow
- Suitable glazing materials

Figure 1. The Strategic Planning Process.

Identify Unmet Customer Needs
Define the Firm's Mission (WHAT)
Set the Firm's Goals (WHY)
Establish the Firm's Objectives (HOW)
Conduct Opportunities and Issues Analysis
Select Basic Strategy
Implement Strategy
Evaluate Strategy

Source: Brumfield (2)

Figure 2. The Business.

Human Resource Plan
Marketing Plan
Production Plan
Financial Plan

Source: Milligan (4)

- Energy conservation considerations
- Environmental control systems, heating and ventilation
- Watering system supply and irrigation systems
- Availability of services, water, electricity, fuel transportation
- Plant production systems, inputs, outputs
- Materials handling systems and labor availability

Requirements for a Greenhouse Production System

There are many pieces to a greenhouse production system puzzle. The diagram in Figure 3 graphically portrays some of the inputs and outputs that need to be considered when planning an expansion to a greenhouse production system. Each of the items mentioned needs to be considered. Some are easier than others because they flow, such as water and air. Others require manual labor and storage facilities. Thinking of the greenhouse as a system can help forestall subsequent problems.

A site survey that includes a topographical map is important so that there are no surprises with runoff, quantities of fill, road access, or neighbor complaints. The elevations on the map should have 1–2 contour intervals. The site plan should accurately show current buildings, roads, and utility entrances. Locations of streams, ponds, and dedicated wetlands are important for runoff considerations and the permitting process, if applicable. If retail operation is part of the plan then more care is needed in planning to satisfy the requirements of codes, public safety, and neighborhood considerations. NRAES 51, *Produce Handling for Direct Marketing* and NRAES 52, *Facilities for Roadside Markets*, contain good planning information for retail operations. Figures 4 and 5, which show some planning concepts, are from NRAES 52. A key to good planning is to arrange the sales area so that employee and plant materials movement do not intersect and interrupt normal customer movement and traffic patterns. When considering sales areas within greenhouse structures, new code proposals might have an effect on the design of the facility. A prudent check by the engineer or the architect involved in the construction of the facility with the local zoning officials is advised. Mercantile applications are particularly subject to scrutiny by code officials.

Figure 3. Parameters Required for a Greenhouse Production System.

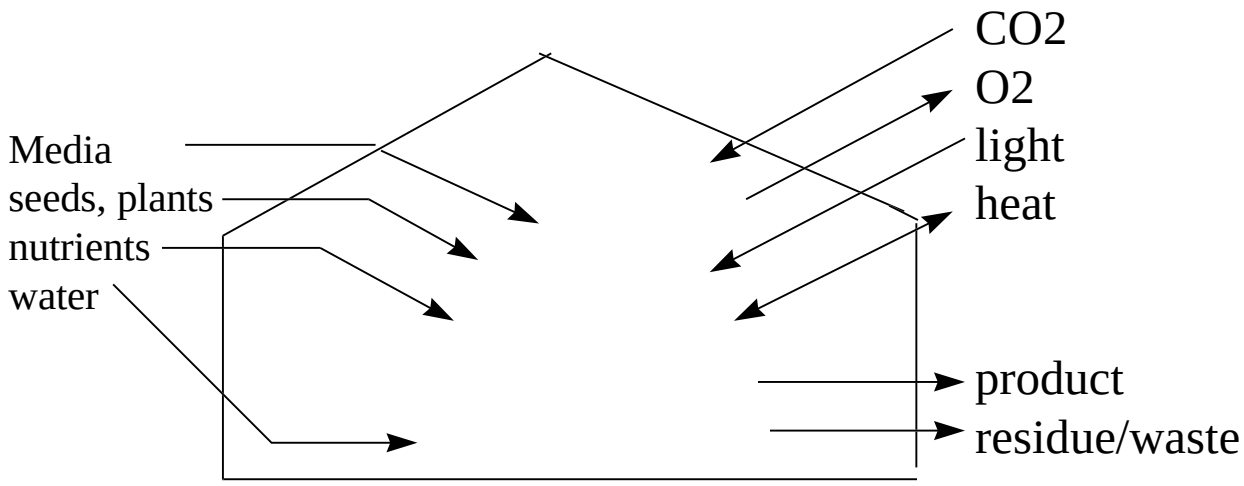


Figure 4.

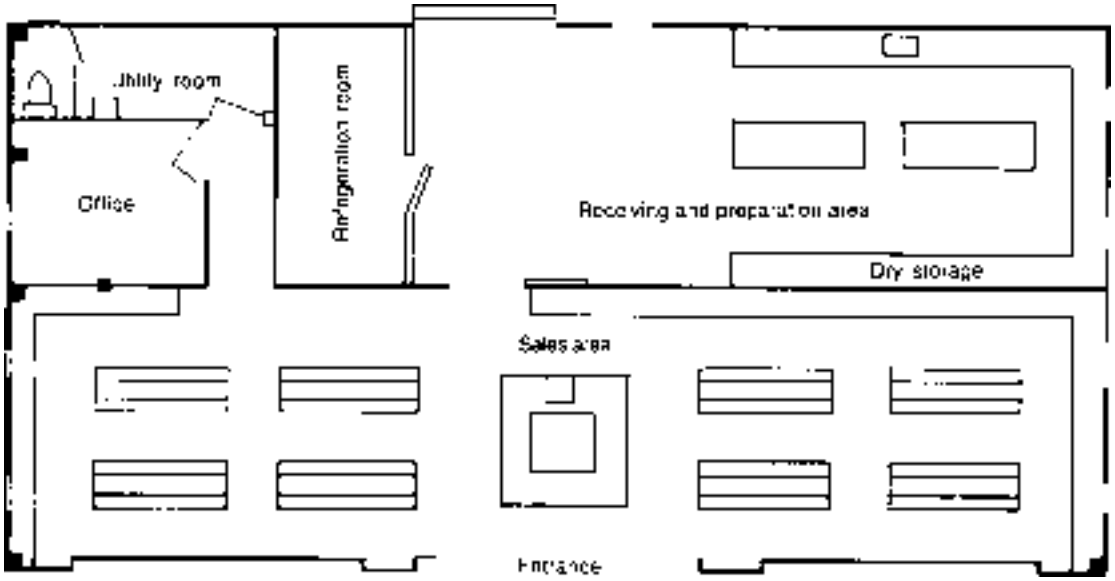
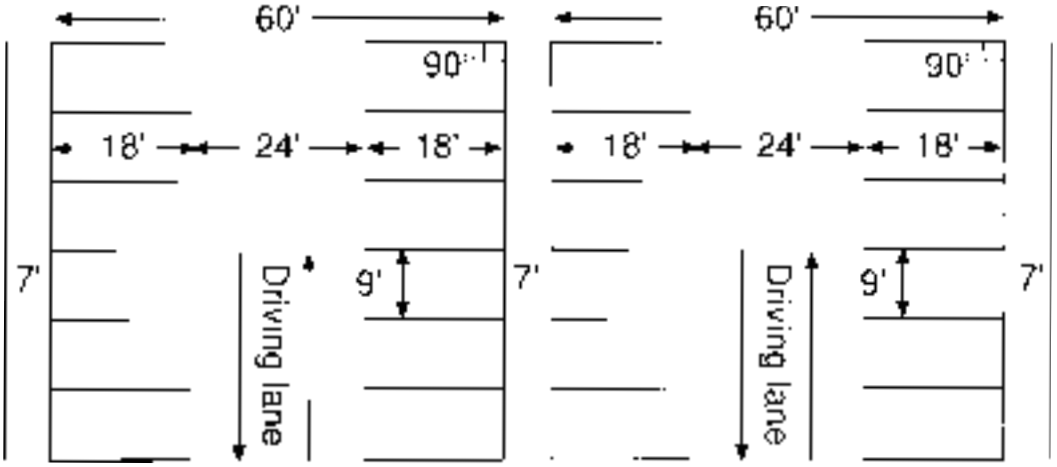


Figure 5.



Key Components for Greenhouse Facilities

The Foundation

With new environmental regulations limiting run-off from greenhouses it is becoming increasingly beneficial to construct a solid concrete foundation for the greenhouse. The walls must extend below frostline and should be 8" wide. Interior walkways should be 4" thick and at least 10 feet wide for vehicle travel.

The Structure

The type of structure should be based upon the growing system, the level of automation, the crops to be grown and the overall physical arrangement possible on the site. These choices determine bay

width and length, gutter height, glazing, and type of ventilation. Hanging baskets can determine gutter height and irrigation booms can require special clearances.

Ventilation and Cooling System

Ventilation systems can be either mechanical or natural with natural being determined mostly by site because of wind considerations. Natural ventilation through side walls is becoming a popular choice, but its appropriateness depends on crops being grown, location, and automation potential.

Heating System

The heating system should be selected based on personal choice and the crop being grown. The initial cost is important but may not be the most important consideration. A uniform crop is a necessity for some growing systems, and the heating and ventilation systems are major players in producing a uniform crop. Heating systems that give good temperature uniformity are preferred.

Thermal Screens or Curtain Systems

A thermal screen that doubles for summer shading is one of the best investments a grower can make. The greenhouse structure must be able to accommodate a thermal screen. If the installation cannot be made at the beginning of the project, the design must include the provisions for it to be added without expensive modification or alteration to the greenhouse at a later date.

Growing Systems

Efficient use of greenhouse space and the cost and energy savings realized are a major considerations for growers. Being able to fill and empty the greenhouse efficiently and quickly is an important consideration. The bedding plant industry is a good example of how mechanization can develop and the need for each piece of required equipment to work in a system to achieve the desired goal of efficient movement and reduced time, effort, and cost. Figure 6 illustrates three current methods of production, which are labor and space efficient. Of these three methods, only the movable bench system may limit speedy removal of the crop unless another overhead conveyance is used to bring the material to the crosswalk.

Environmental Control System

Quality analog and computer systems are available that accurately sense and control both aerial and soil temperatures. Computer systems have the advantage of recording data for subsequent use in evaluating plant performance or identifying problems with the growing system.

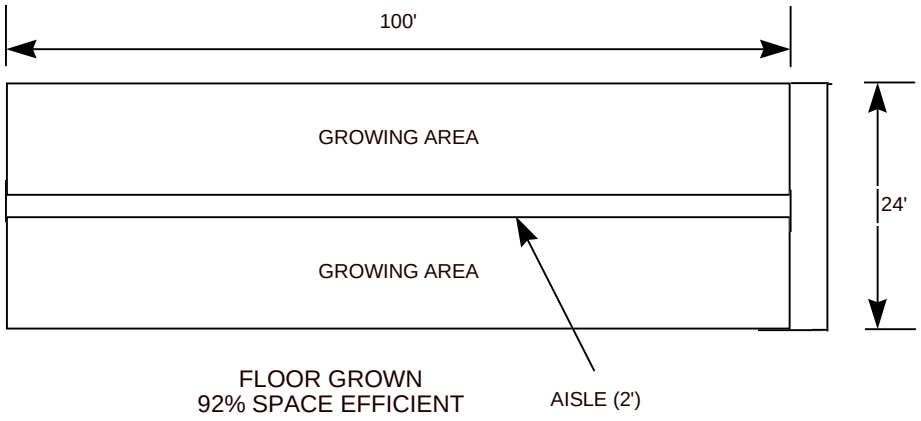
Adequate Water Supply

In siting the greenhouse consideration must be given to the water supply. Is there an adequate water supply? In some areas of New Jersey water availability may be a limiting factor in greenhouse establishment and production. All users of agricultural or horticultural water that exceed 100,000 gallons of use per day must first obtain an agricultural certification for the privilege to divert water from ground or surface sources pursuant to New Jersey statute Chapter 20.

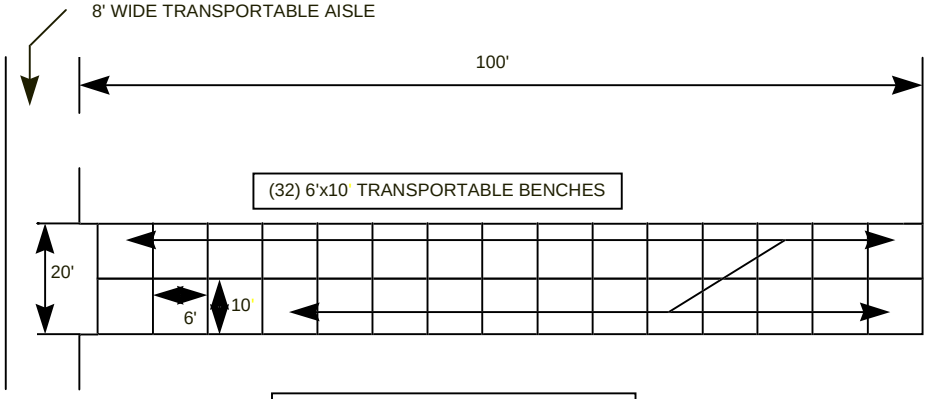
This process includes public notice for approval. Adequate water must be available in the aquifer to supply this new source(s) of diversion. This will be determined by NJDEP Bureau of Water Allocation. These water rights are not automatically approved and require a lengthy permit process. NJDEP will not allow new diversions if the total water use of all diversions in that aquifer exceed more than 25% of the recharge. This may limit the granting of water certifications in certain areas of N.J. Water availability via certification should be determined prior to the site purchase and/or greenhouse construction or the grower will risk not obtaining a water certification for the volume of water needed.

The Rutgers Cooperative Extension agricultural agent in your county can assist in determining water use requirements for the operation and the application process for certification.

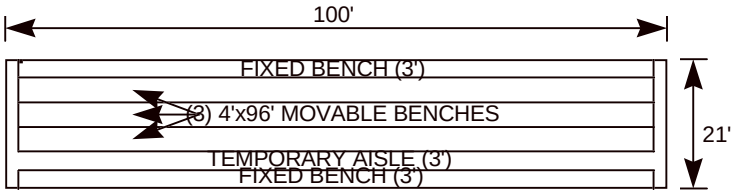
Figure 6.



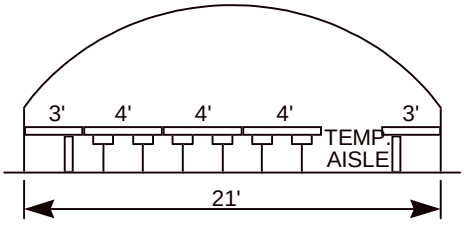
FLOOR GROWN
92% SPACE EFFICIENT



TRANSPORTABLE BENCHES
93% SPACE EFFICIENT



MOVABLE LONGITUDINAL BENCHES
82%SPACE EFFICIENT



Irrigation Systems

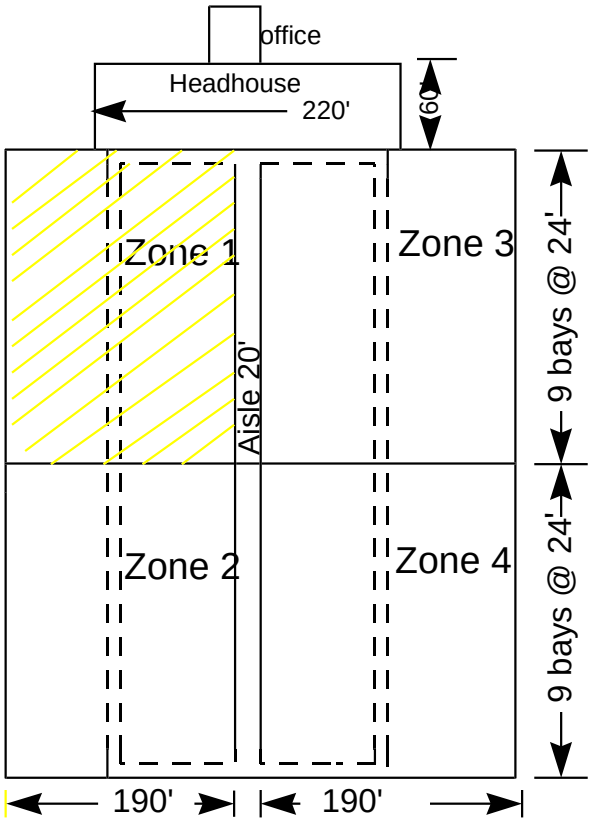
Irrigation systems vary in design and layout. Automation is a major consideration, a greenhouse design should be chosen that allows for future installations of automatic control and equipment. The fertilizer injection system must be compatible with the installed irrigation system and must be understood by the operator so that expectations of its performance are realized.

Utilities Installations

The installation and availability of common utilities, (water, fuel, and electricity), is of utmost importance, particularly when thinking about capacity for future expansion. The use of appropriate electrical installation practices within the greenhouse can forestall future safety and operation problems as well as maintenance and breakdown situations. Each electrical installation should have provisions for the addition of an emergency generation system, preferably to be installed when the greenhouse is constructed.

Figure 7. Phase One:

Construct Zone 1.



Prepared by John Hoogeboom, Agronomico International.

A Suggested Plan for Constructing a 4-Acre Greenhouse Facility

Figures 7 through 12 illustrate a five-phase approach to constructing a greenhouse facility. The most important part of the facility is the greenhouse, because it produces the revenue. That

Figure 8. Phase Two:

Construct Zone 2.

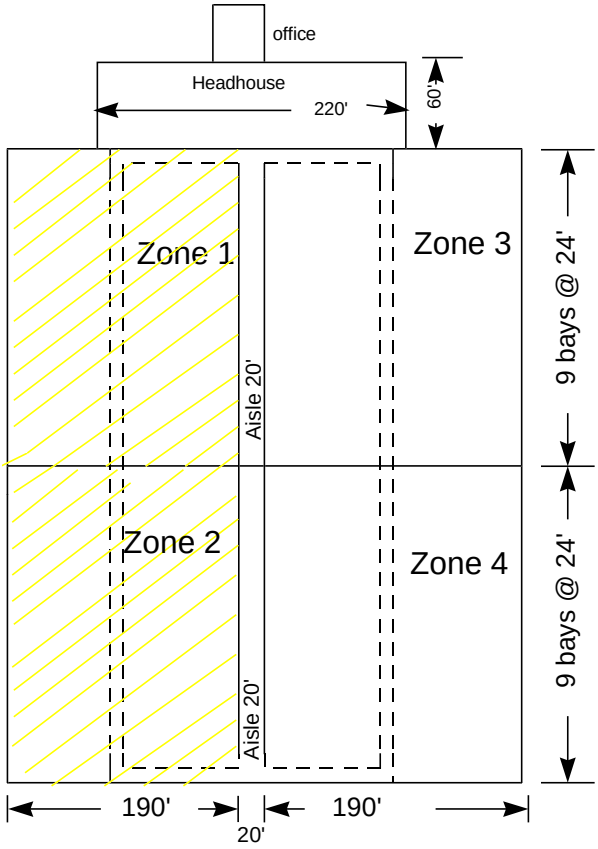


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Figure 9. Phase Three:

Construct Zone 3.

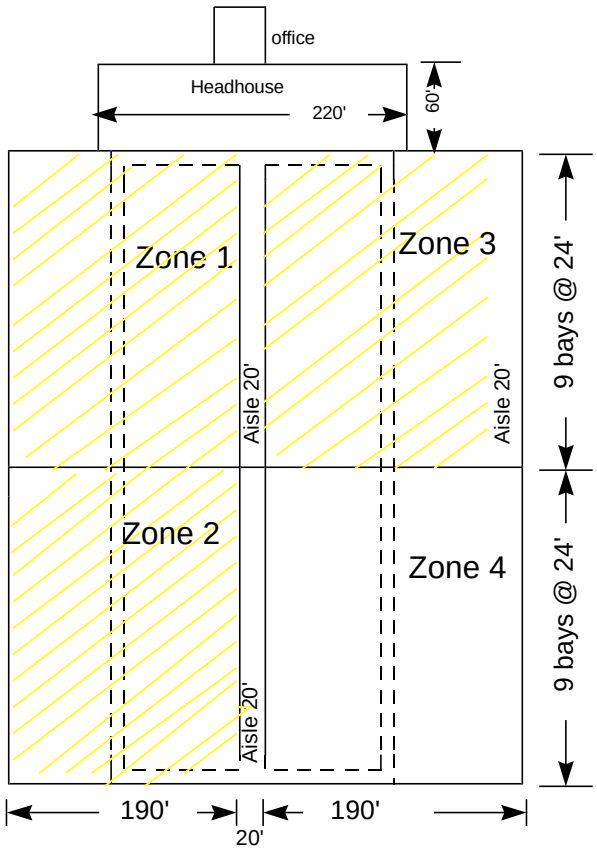

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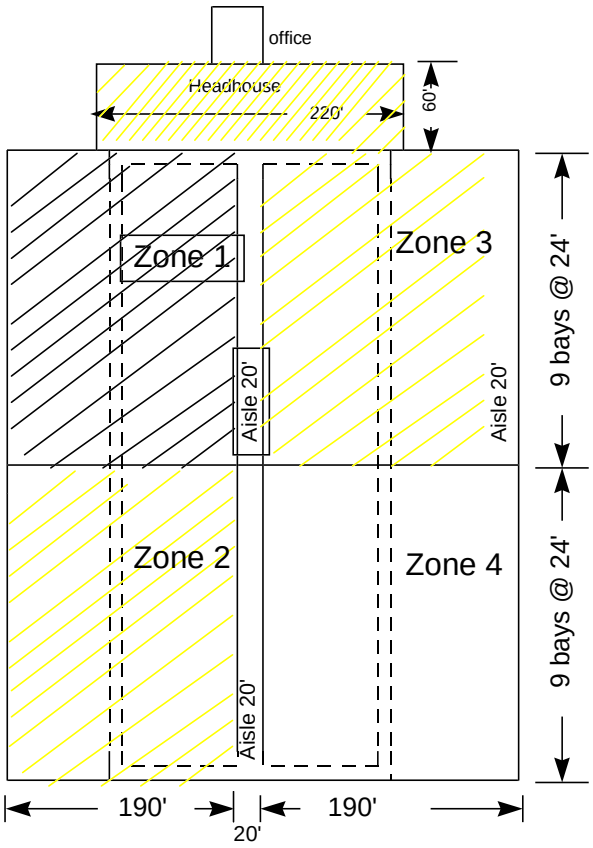
Figure 10. Phase Four:

Construct Headhouse.



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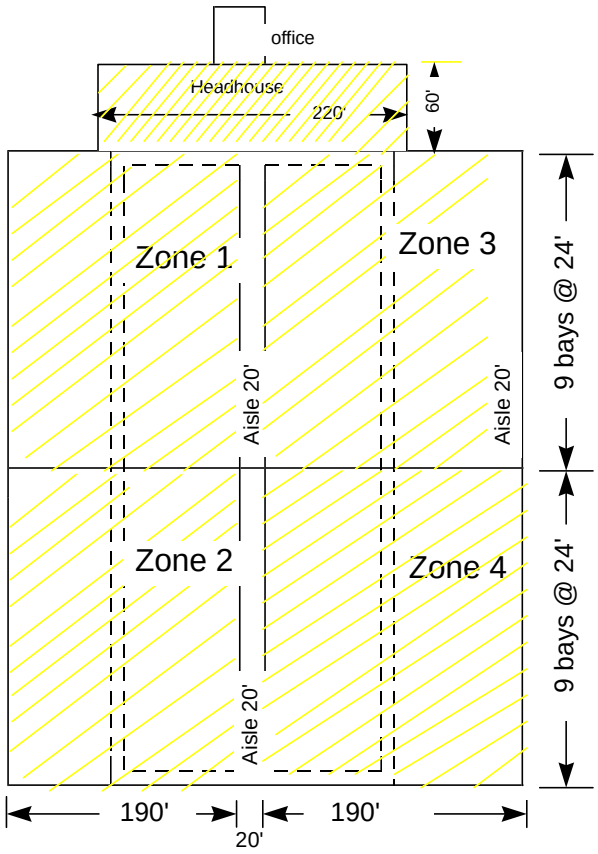
is why the greenhouse itself is used as the headhouse during the early stages of development. By the time the two- or three-acre complex is underway, the headhouse will be sorely needed. It can be argued whether the headhouse should come after completing phase two or three.

The selection of equipment and facilities to operate the greenhouse is a major and difficult decision. For instance, should a transportable bench system be installed before an excellent heating system? The answer is, unless the greenhouse has an excellently controlled environmental heating and cooling system, don't waste money on a transportable bench system. Consider a greenhouse with transportable benches and a poorly controlled heating system. The produced crop will not be uniform from end to end. Consider the problem of moving transportable benches to the headhouse and having some of the crop ready, some almost ready, and the rest at other stages. How do you handle the crop? Several paths of product travel have to be established. This is expensive, inefficient, and very unprofitable. A transportable bench system must deliver 90–95% uniformity to the headhouse or there will be nightmares with the materials handling system. The answer to the hypothetical questions raised above is, of course, there has to be an excellent heating system installed before a transportable bench system should be considered.

There are other questions to be asked. Can you grow on the floor before you install a floor heating

Figure 11. Phase Five:

Construct Zone 4; Complete 4-Acre Project.



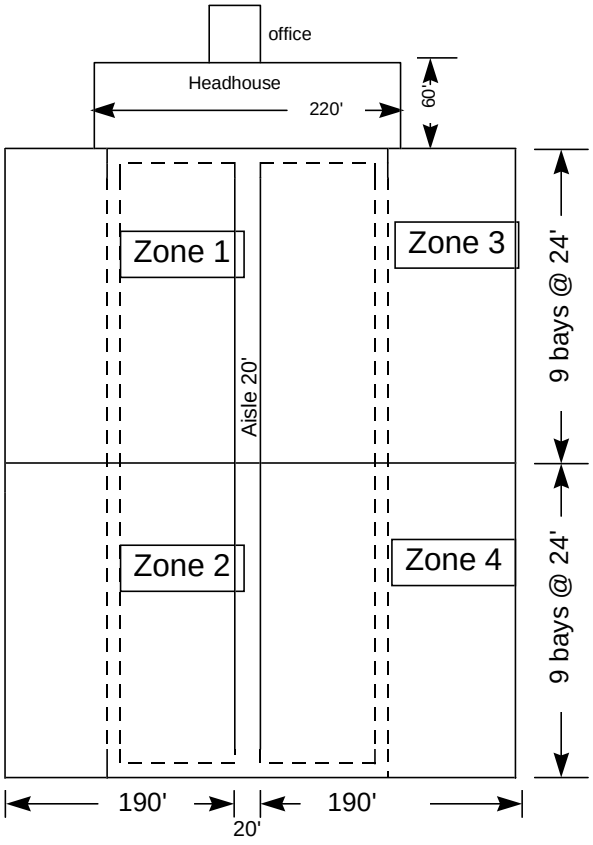
Prepared by John Hoogeboom, Agronomico International.

system? The answer is, probably not for maximum growth and profit.

Summary

A good master plan is composed of many components. Considerable thought and evaluation has to be made before the plan is completed and before the intended program of growth or expansion is undertaken. The important issues include a business plan, a site evaluation, an evaluation of the type of growing structures, equipment desired and required and the impact the expansion might have on the community at large. The listed references contain information helpful in preparing a master plan for the grower who would like to enlarge current facilities or erect new ones.

Figure 12. Master Plan.



Proposed plan for a 4 acre greenhouse complex constructed in 5 phases

Phase 1 zone 1

Phase 2 Zone 2

Phase 3 Zone 3

Phase 4 headhouse

Phase 5 Zone 5

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Figure 13. Greenhouse Checklist.[1]

Permits

Site Preparation
- Leveling
- Drainage

Utility Provisions
- Electricity
- Potable water
- Irrigation water
- Telephone
- Natural gas
- LP gas storage tank
- Fuel oil storage tank
- Sewage system

Greenhouse Foundation
- Perimeter knee wall
- Walkways
- Concrete floors
- Splash ways for roof runoff
- Soil-bearing capacity
- Interior post design

Greenhouse Structure
- Roof glazing
- Side-wall glazing
- End-wall glazing

Ventilation and Cooling Systems
- Gable ventilation system
- Exhaust fans
- Pad system
- Roof ventilation system
- Natural ventilation system
- Horizontal air flow fans
- Fog cooling system
- Roof system sprinkler

Curtain Systems
- Energy retention systems (thermal screens)
- Inside shade system
- External shade system
- Gable shade system
- Blackout system/day length control

Heating Systems
- Gas fired unit heater
- Oil fired unit heater
- Hot water unit heater
- Hot water boiler unit
- Perimeter piped hot water system
- Overhead piped hot water system
- Under-bench system piped hot water
- In-floor system piped hot water
- Pipe/rail heating system

Irrigation Systems
- Hand watering
- Overhead spray nozzle
- Floor sprinkler
- Irrigation boom (movable)
- Low-level spray nozzle
- Flooded floor
- Drip irrigation

Fertilizer Injection
- Proportioners
- Injection units
- Liquid fertilizer injection system

CO_2 Injection Units
- Pure CO_2 distribution system
- CO_2 burners
- Flue gas CO_2 extraction system

Greenhouse Lighting
- Supplementary lighting system
- Cyclic lighting system
- Walkway and security lighting

Growing Systems
- Greenhouse floor
- Flooded greenhouse floor
- Fixed tables or benches
- Rolling tables
- Mobile or transportable tables
- Hanging basket systems
- Vegetable growing system

Environmental Control units
- Analog controllers
- Computer based controllers
- Alarm systems

Electrical Installations
- Distribution boards
- Stand-by power generator
- Interface panels
- Service entrance equipment
- Main voltage cable and box
- Low-voltage cable

Misc. Installations Equipment

Site Finishing

[1]*Courtesy John Hoogeboom CEO, Agronomico International, Hendersonville, N.C.*

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