JAMAICA
SMALL BUSINESS EXPORT DEVELOPMENT PROJECT

CONTRACT NUMBER 532-0135-C-00-4360-00

ACTION PLAN FOR IRRIGATION SYSTEM DESIGN, INSTALLATION, AND MAINTENANCE TRAINING ON SELECT JAMAICA FARMS (MEMBERS OF JAMAICA EXPORT ASSOCIATION)

PREPARED IN ASSOCIATION WITH

THE UNITED STATES AGENCY FOR
INTERNATIONAL DEVELOPMENT
JAMAICA MISSION

PREPARED BY
DONALD J. BROSZ
CONSULTING IRRIGATION ENGINEER

SUBMITTED BY
CHEMONICS INTERNATIONAL CONSULTING DIVISION
WASHINGTON, D.C.

APRIL, 1995

TABLE OF CONTENTS

SCOPE OF WORK

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT

CONSULTING IRRIGATION ENGINEER

BACKGROUND

Under the export expansion component of the Jamaica Export Association/Small Business Export Development Project (JEA/SBED) "Strategy and First Annual Work Plan: January 1, 1995 - December 31, 1995", the agribusiness section describes work the SBED project will undertake which will support increased exports of non-traditional fresh produce and processed food products. The objective of the export expansion component is to "target export-hungry enterprises" operating in the agribusiness sector and work with them, within the context of a venture plan, to achieve increases in exports.

In Jamaica at the present time, there are a number of farms that are positioned for large-scale export growth, either as fresh or value-added processed items, that face major constraints revolving around the appropriate design, purchase, installation, operation and management of irrigation equipment and on-farm maintenance systems. In essence, the parameters of the problem are as follows:

* The farms have source and/or already purchased necessary equipment and systems, but have not been able to complete installation and setup successfully for various reasons.

* The equipment is installed and ready to go but cannot be put into operation unless and until the owners can be assured that they have the necessary technical expertise on tap to ensure successful operation: until this expertise is available, they are not going to shift from their current systems.

* The owners want to hire and train individuals to run and manage their systems but are not sure where and how to start -- either with judging the level of skills which the candidate should bring to the job and those which could be added through training and/or with providing the needed training.

SBED is ideally positioned to assist companies with irrigation problems to resolve or make progress towards resolving the above constraints. The attraction for SBED is that these companies will be in a position, with proper irrigation, to realize increased exports within a relatively short time frame.

PROCEDURE

* The consulting Irrigation Engineer will conduct personal visits to the selected Jamaican farms to work with the respective farm owners, managers and/or irrigation workers to identify irrigation constraints and train, where appropriate, the irrigation workers on such farms.

* The consulting Irrigation Engineer will provide a written report of activities and recommendations for each individual farm.

CONSULTING IRRIGATION ENGINEER'S SCHEDULE

March 13, 1995: Travel from Laramie, Wyoming to Kingston, Jamaica.

March 14, 1995: Met with USAID/Jamaica Project Officer, Mike Kaiser along with SBED Chief of Party, Steve Wade for security and SBED project orientation.

Visit to Morant Farms - with General Farm Manager, Mr. Wayne Peart.

March 15-18 & 20, 1995: Worked with Morant Farms, Morant Bay - personal visit to the farm, observed the farm's irrigation systems, irrigation management and operation practices. Trained farm's irrigation workers at all opportunities and conducted formal training sessions for the following Morant Workers:

Mr. Wayne Peart, General Farm Manager
Mr. Grant Hilbert, Irrigation Supervisor

Mr. Neville Davidson, Field Supervisor
Mr. Lloyd Browm, Field Supervisor
Mr. Ephram Carr, Irrigation Worker
Mr. Anthony Walcott, Field Supervisor
Mr. Alfred Johnson, Irrigation Worker
Mr. Garth Skeene, Irrigation Worker
Mr. Anthony Mitchell, Irrigation Worker
Mr. Winston Wright, Farm Shareholder

March 21 -25 & 27 - 28, 1995: Worked on the Blooming Things Farm, Bog Walk - personal visit to the farm, working with Ms. Hilda Vaughan, General Farm Manager - observed the farm's irrigation system, irrigation management and operation practices, reviewed irrigation system designs for proposed irrigation expansion, inventoried purchased irrigation equipment and supplies for proposed installation and expansion, and supervised installation of some irrigation equipment. Trained farm's irrigation workers at all opportunities and conducted formal training session for the following:

Ms. Hilda Vaughan, General Farm Manager
Mr. Richardo Whyte, Irrigation Supervisor
Mr. Morris West, Irrigation Worker
Mr. Castley Smith, Irrigation Worker
Mr. Lester Jones, Irrigation Worker

March 29 - April 1, 1995 :

Worked on Jamaican Floral Exports Farm, Ocho Rios - personal visit to the farm to observe farm's irrigation system, irrigation management and operation practices. Trained farm's irrigation workers at all opportunities while working on the farm. Those farm workers includes the following:

Mr. Robert Facey, Managing Director
Mr. Lloyd Facey, Farm Shareholder
Mr. Michael Peart, Operations Manager
Mr. Vinney Williams, Irrigation Supervisor

April 3, 1995:

Visited the Green Valley Farm, Harmony Hall, with Ms. Tanya Brown, Farm Owner to observe the land area being proposed for future irrigation development.

April 4, 1995:

Kingston - office, preparing reports.

April 5, 1995:

Kingston - visited with the following people:

Mr. Michael White, Consulting Hydrologist
Mr. Lance Powell, Owner, Caribbean Industrial Equipment (Irrigation Dealer)

Office - prepare reports.

April 6, 1995:

Kingston - visited with the following people:

Mr. Basil Fernandez, Director, Underground Water Authority
Mr. Shelom Hodala, Owner, Jamaica Drip Irrigation (Irrigation Dealer) - Mandeville
Mr. Milton Henry, Assistant Director, National Irrigation Commission
Mr. Peter Hughes, Consulting Engineer, Wallace Evans Jamaican Ltd.
Mr. Leonard Ramdail, Owner, Ladimar Irrigation (Irrigation Dealer)

Mr. Lucius White, Owner, Pumps and Irrigation (Irrigation Dealer)

April 7, 1995: Kingston - visited with the following:
Dr. Joseph Lindsay, Professor and Ms. Shelena Topper, Program Coordinator, University of West Indies (Irrigation Short Course)
Ms. Tanya Brown, Owner, Green Valley Farm
Office - prepare reports

April 8, 1995: Revisited Morant Farms, Morant Bay with Mr. Wayne Peart, General Farm Manager and Mr. Winston Wright, Farm Shareholder.

April 10, 1995: Revisited Blooming Things Farm, Bog Walk with Ms. Hilda Vaughan, Mr. Richardo Whyte, Irrigation Supervisor and Mr. Lester Jones, Irrigation Worker.

April 11, 1995: Visited Mistflora Farm, Rock Hall with Ms. Dawn Ottey, Owner/Manager to observe irrigation system, management and operation practices and discuss proposed future irrigation expansion.

April 12, 1995: Visited Tropicrop Mushrooms/Kircamp Properties farm, Blue Mountain with Ms. Jennifer Lyn, Owner/Manager to observe existing irrigation systems and discuss proposed irrigation system changes.

April 13, 1995: Kingston - Debriefing with USAID, Project Officer, Mr. Mike Kaiser; USAID, Officer, Ms. Valerie Marshall and SBED, Chief of Party, Steve Wade.

Visited with Elon Beckford, Morant Farms Shareholder.

Office - prepare reports.

April 14, 1995: Kingston - Office - prepare reports.

April 15, 1995: Kingston - Office - prepare reports.

April 17, 1995: Travel from Kingston to Laramie, Wyoming.

MORANT FARMS

P.O. BOX 67

ST. THOMAS

MORANT BAY, JAMAICA

IRRIGATION REPORT

MARCH 14 - 20 AND APRIL 8, 1995

DONALD J. BROSZ
CONSULTING IRRIGATION ENGINEER

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT

CHEMONICS INTERNATIONAL CONSULTING DIVISION
WASHINGTON, D.C.

5

MORANT FARMS

P.O. BOX 67

ST. THOMAS

MORANT BAY, JAMAICA

SMALL BUSINESS DEVELOPMENT PROJECT IRRIGATION SCOPE OF WORK

The Consulting Irrigation Engineer will carry out the following activities:

* Meet with the owners and managers of Morant Farms, and other participating farms, to gain first-hand information on the steps which have been carried out to date regarding the installation of an irrigation system.

* Design an approach to the overall project which calls for involvement of selected trainees in the on-site project activities as a way of learning about and testing their capacities in field situations.

* With Morant Farms' selected group of trainees, conduct in-depth, on-site visits to get a first-hand picture of the status of the existing irrigation systems installation activity and make specific recommendations with regard to next steps. At the same time, inventory related equipment and determine level and type of maintenance support which would be required from an on-farm irrigation supervisor.

* If appropriate, supervise final irrigation installation and set up for Morant Farms and/or ensure that steps for final set up are in place and can be followed up from Jamaica.

* Provide back-up classroom training and exercises to test and augment the skills, as necessary, of candidates for the irrigation supervisor position. (If the need for additional training is identified, work with SBED management to locate a suitable source to provide such training).

* Rate Morant Farms' trainees in terms of their strengths. Assist management to develop a job description which meets the requirements of the farm, and participate in the final selection of an irrigation supervisor from among the trainees.

MORANT FARM IRRIGATION RECOMMENDATIONS

FARM IRRIGATION SYSTEM OPERATIONS, MANAGEMENT AND MAINTENANCE

* A pipeline water flow meter and pressure gauge be installed at the pump discharge on all irrigation pumping plants.

* One irrigation worker be designated and assigned the responsibility for walking fields during irrigations, observing and noting irrigation system problems, be responsible for taking soil moisture samples and recording the findings, using the iron rod to determine depths of irrigations, record pressure gauge readings, record pipeline water flow meter readings, record watt-hour readings and observe crop conditions. This individual be in continual communication with the General Farm Manager and Farm Irrigation Supervisor to inform such on system problems, maintenance requirements and irrigation water application requirements and conditions.

* Provide the above designated irrigation worker with appropriate irrigation equipment and supplies to efficiently perform his duties such as a soil auger, an iron rod, sprinkler nozzle pressure gauge and pipeline water flow meter and pressure gauge located at each irrigation pumping plant and a supply of replacement parts (gaskets, sprinkler heads, etc.).

* Immediately repair all pipeline and water control valve water leaks for efficient irrigation water application.

* Use the irrigation schedules developed for the farm by the consulting Irrigation Engineer as a guide - supplement the guide by taking soil samples using the feel and appearance method to more accurately predict times when irrigation water needs to be applied to each field and use the irrigation rod to more accurately determine when irrigations can be stopped.

* To keep the sprinkler nozzle operating pressures more equal, when possible, turn on approximately half the sprinklers nearest to the irrigation pumping plant and the other half fartherest away from the irrigation pumping plant while irrigating.

* During months when irrigation systems need to be operated during the night and/or holidays, consideration may need to be given for paying incentives to the irrigation workers during those times.

IRRIGATION MANAGEMENT INFORMATION

MORANT FARMS

MORANT BAY, JAMAICA

MARCH 14 - 20 & APRIL 8, 1995

IRRIGATION PUMPING PLANT

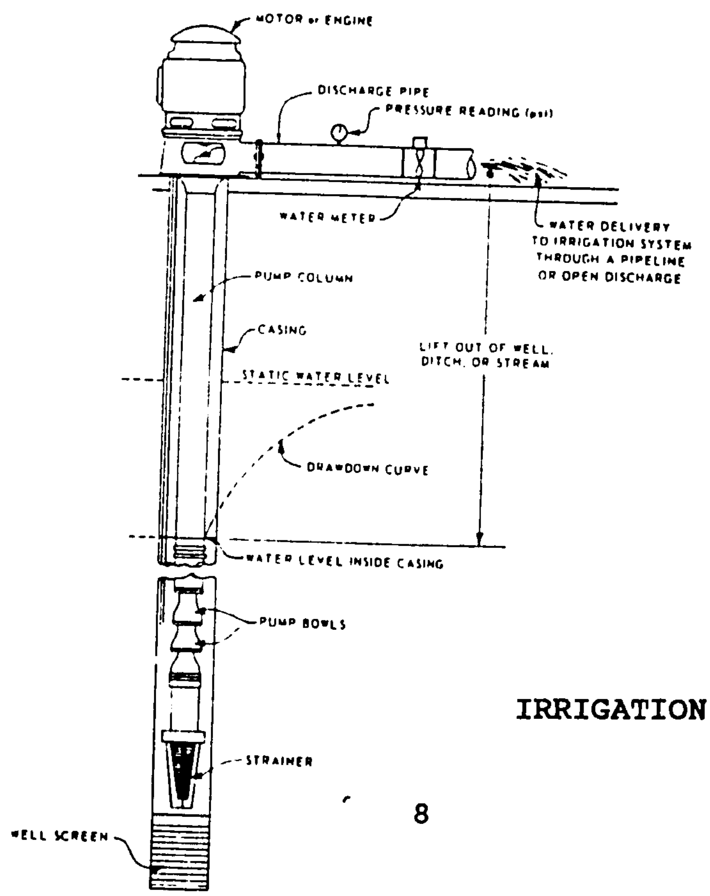
The energy costs for operating an irrigation pumping plant are a major cost to an irrigator. There are four factors that determine the power and energy requirements of an irrigation pumping plant. They are:

1. The quantity of water being pumped generally expressed as gallons per minute (gpm) when an irrigation pumping plant is in operation

2. The depth from which water is lifted in the well to the discharge side of the pump (distance between the water surface in the well while the pump is operating and discharge point at the pump).

3. The pressure at the discharge point of the pump when it is operating, as expressed in pounds per square inch (psi).

4. The efficiency of the irrigation pumping plant expressed in percent.



IRRIGATION PUMPING PLANT

The above figure shows a typical operating irrigation pumping plant.

The distance water is lifted out of the well plus the pressure at the pump discharge (2 and 3 above) is expressed as total lift in feet (often referred to as total dynamic head - in this report it will be referred to as total lift). This lift is shown in the above irrigation pumping plant figure. The distance the water is lifted to the pump discharge, measured in feet - the pressure reading, measured in pounds per square inch (psi). Everything need to be in feet. **To convert psi to feet, multiply the psi reading by 2.31.** For example, a pressure reading of 70 psi is equal 162 feet (70 x 2.31 = 162). Adding the two, distance water is lifted out of the well in feet (this distance should be measured by the well driller upon completion of the well) plus the discharge pressure in feet, equals total lift in feet. There is a small additional loss in the pump column or suction side to the pump that should be added to the total lift. However, this is often small and can be discounted for wells that are very shallow as on the Morant Farms.

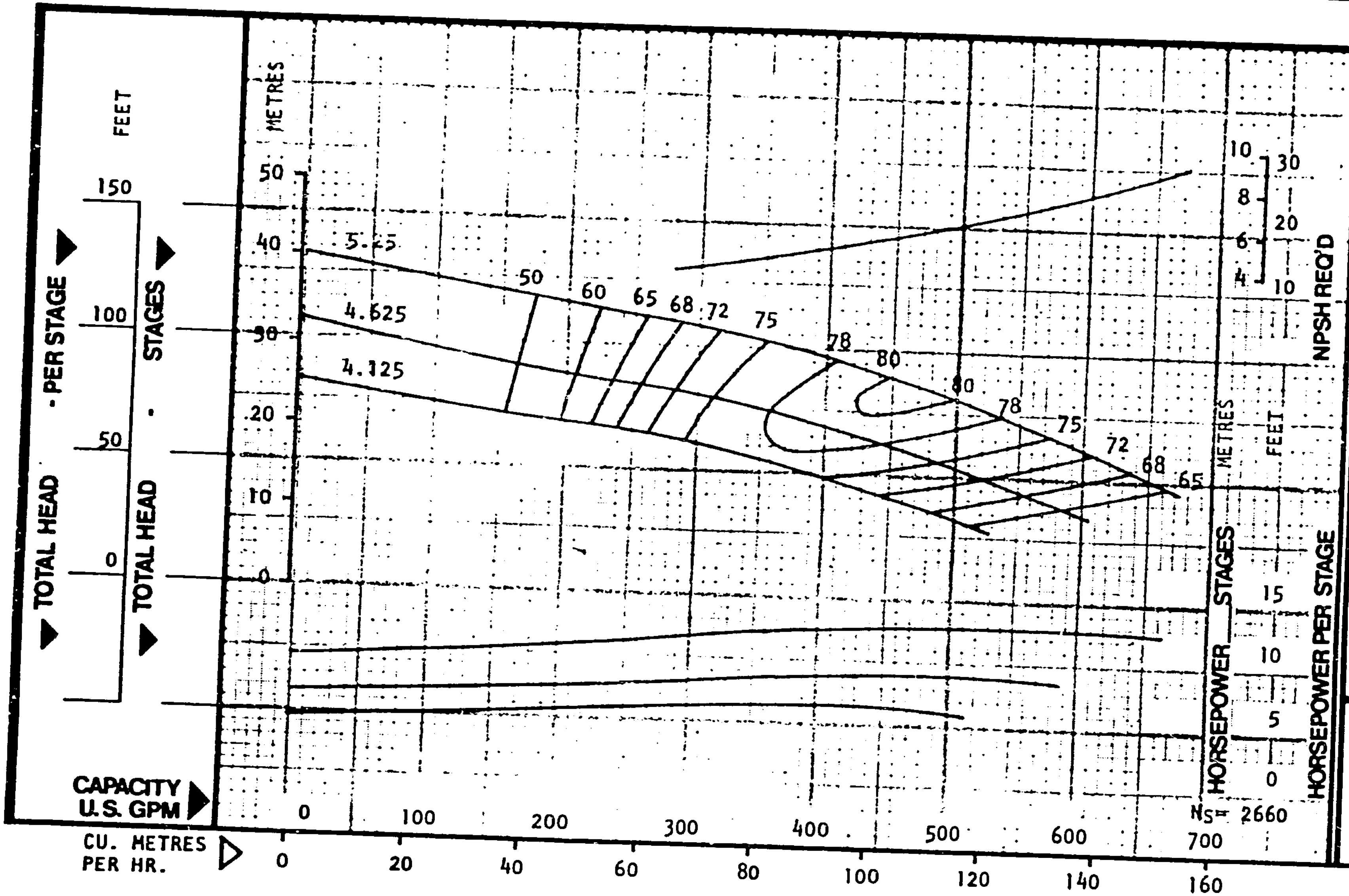
Efficiency of an irrigation pumping plant is an indicator as to the ability of the total irrigation pumping plant to deliver a quantity of water at a required total lift using the least amount of energy. No irrigation pumping plant is 100% efficient, not even a perfectly designed new irrigation pumping plant. Energy is lost within the electric motor or internal combustion engine because of its operating characteristics (slippage, bearing friction, etc.). Power is also lost between the drive shaft and the pump. Energy is also lost in the pump because of its operating characteristics, friction in the well screen, etc. **A typical irrigation pumping plant, properly designed, will operate at approximately 66% efficiency (electric motor 88% and pump 75% = 0.88 x 0.75 = 0.66).** A more accurate irrigation pumping plant efficiency can be obtained from a pump performance curve available for every pump. An irrigator should request a copy of the pump performance curve from the dealer at the time the pump is purchased and kept in the irrigation system file for future reference. An example of a pump performance curve is attached.

MORANT FARMS IRRIGATION PUMPING PLANT

Pump #1 is used to pump water for a high pressure volume overhead sprinkler system and for a few acres of a medium pressure solid set under canopy sprinkler system. The irrigation pumping plant has a pipeline water flow meter and a pressure gauge located near the pump discharge. Readings were taken during the consulting Irrigation Engineer's visit to the Morant Farms while the irrigation pumping plant was in operation. The measurements indicated the pump was discharging 550 imperial (660 U.S.) gallons/minute (gpm) at a pressure of 65 pounds per square inch

GOULDS PROPOSAL NO	GOULDS SO NO	INQUIRY NO	CUSTOMER PO NO	PO DATE	ITEM NO	CUSTOMER

PROJECT	SERVICE	GPM CAPACITY	FT TDH	% EFFICENCY	RPM



Curve No. 1014-1

Size: 8JLC

RPM: 3500

EFFICIENCY CHANGE

STGS.		
	1	-4
"	2	-2.5
"	3	-1.5
"	4	-1.0

Perf. based on: Brz. Impellers & C.I. Vitriglass Enamelled Bowls.

Impeller: CLOSED

K= 4.0 LBS./FT.
6.0 Kg./M.

K(Bal.)=

GOULDS PUMPS
VERTICAL PUMP DIVISION
CITY OF INDUSTRY, CALIFORNIA

Characteristc based upon pumping clear, non-aerated water.
Rating point only is guaranteed. Column losses not included.

(psi). The 65 psi is equal to 150 feet (65 x 2.31 = 150). Morant Farms workers indicated the lift from water level in the well to the discharge pipe of the pump is approximately 14 feet. The total lift for the #1 pumping plant is equal to 164 feet (150 + 14 = 164). A pump performance curve the irrigation pumping plant #1 is not available in the Morant Farms file. The assumption is that the irrigation pumping plant is operating at 66% efficiency as discussed above for a typical irrigation pumping plant. Horsepower required to operate the #1 irrigation pumping plant can be calculated with the following formula:

$$\text{Horsepower (HP)} = \frac{\text{gallons/minute pumped x total head in feet}}{\text{3960 x irrigation pumping plant efficiency}}$$

$$\#1\ \text{HP} = \frac{660 \times 164}{3960 \times 0.66} = 41$$

Kilowatts used per horsepower equals 0.746. Thus the 41 HP electric motor on the #1 pump should be using 31 kilowatts per hour.

The #1 pump is being driven by a 75 horsepower electric motor. The operating characteristics of an electric motor is such that even though the motor is 75 horsepower, it will only use or draw the amount of kilowatts of the 41 horsepower required which is 31 kilowatts or whatever load is needed at the time.

The Morant Farms irrigation pumping plant #3 supplies water to all solid set medium pressure under canopy sprinklers. There is a pressure gauge installed near the discharge side of the irrigation pumping plant, but no pipeline water flow meter. However, the quantity of water that is being pumped can be obtained in another way and that is to take pressure readings at the sprinkler nozzles. Knowing the size of the nozzles, one can determine from a sprinkler nozzle chart, the flow of each nozzle. The quantity of water being pumped is the flow per nozzle times the number of nozzles operating during the irrigation set.

Sprinkler nozzle discharges and pressures for varies nozzles is shown in the following chart. The under canopy sprinklers on the Morant farm are the grey or 9/64 inch sizes.

PERFORMANCE TABLE FOR SINGLE NOZZLE MODEL

Noz. Press PSI	#7 Noz. 7/64" Lime		#8 Noz.* 1/8" Lavender		#9 Noz 9/64" Grey	
	GPM	DIA	GPM	DIA	GPM	DIA
25	1.7	80	2.3	84	2.9	89
30	1.9	81	2.5	86	3.2	91
35	2.1	82	2.7	88	3.4	93
40	2.2	84	2.9	89	3.6	94
45	2.3	85	3.1	90	3.8	95
50	2.4	86	3.2	91	4.0	96
55	2.6	87	3.4	92	4.2	97
60	2.7	88	3.6	93	4.4	98
65	2.8	89	3.7	94	4.6	99
70	2.9	90	3.8	95	4.8	100

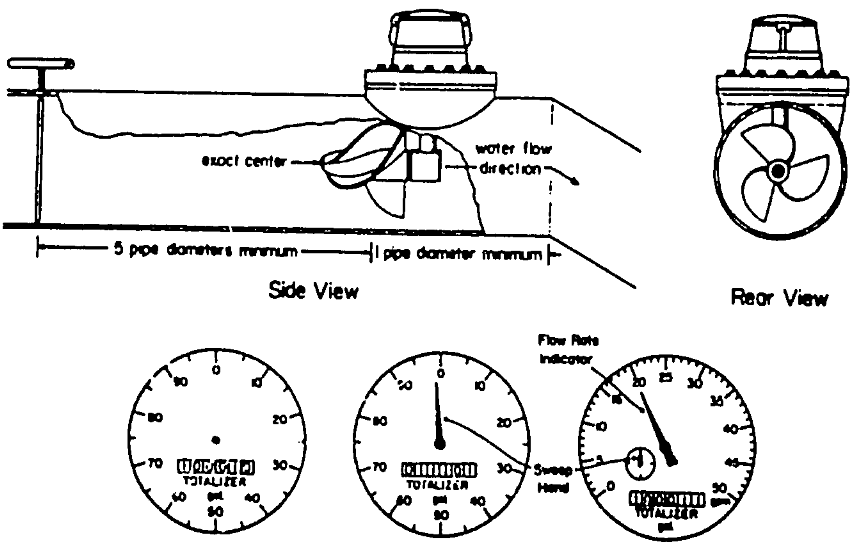
* Standard Nozzle Sizes   Diameter Shown in Feet   Diameter Measured at 12 Feet Sprinkler Height

The pressure measured at pump #3 was 73 psi during operation. Pressure at the sprinkler nozzles was also measured. The nozzle pressures varied between 26 and 19 psi. This should not be. The consulting Irrigation Engineer determined the sprinkler system pipe sizes are adequate and there should not be such a large pressure drop from the pump to the sprinkler nozzles (73 psi at the pump, down to 26 and 19 psi at the sprinkler nozzles) as measured in the field. The only thing that can be taking place is that there must be numerous water leaks in the underground pvc pipelines. Field inspection indicated water leaks at the "T" couplings at many of the riser pipes and in other places along a number of pipelines.

There are no other options available to measure the pump #3 discharge. Neither a pipeline water flow meter or a pump performance curve for pump #3 is available, Thus, no accurate HP determination can be made for the #3 irrigation pumping plant. This, also means the consulting Irrigation Engineer will be unable to develop an appropriate irrigation scheduling program for this irrigation system.

MEASURING INSTRUMENTS

Two measuring instruments on an irrigation pumping plant which can be valuable equipment to the irrigator are a pipeline water flow meter and a pressure gauge installed in the discharge pipe of the pump. As daily or periodic readings are made of these two measuring instruments, accurate quantity of irrigation water delivered and available can be determined. Very important also is the irrigator can note changes that may occur in the measuring instrument readings, especially when such readings begin to decrease. This indicates that problems may be developing in the irrigation pumping plant such as pump wear or in the irrigation system such as water leaks in the pipes, etc. A typical pipeline water flow meter is shown as follows:



PIPELINE WATER FLOW METER

The Morant Farms has two other irrigation pumping plants available. On one irrigation pumping plant, the electric motor is burned out. The other is powered by a diesel engine, still in good running condition. However, both are centrifugal pumps which are primarily surface water pumps. The centrifugal pumps can lift water efficiently from only about 15 feet. The deep well turbine pumps as presently installed on the Morant Farm wells are what is required for the Farms irrigation systems.

FUEL AND POWER CONSUMPTION COMPARISONS

Attached is a table comparing the fuel and power comparisons for various irrigation pumping plant power units. An irrigator can use this table to compare the cost of energy between various power units and select the one that costs the least to operate for the conditions on the individual farm.

IRRIGATION REQUIREMENTS

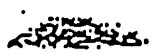
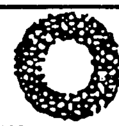
No matter which irrigation methods and practices are used, it is necessary for the irrigator to understand some basic principles about soils and plants in order to obtain maximum efficiency of the resources and, therefore optimum production.

Soils

In irrigation, the soil's most important function is to store water and nutrients for the plants. A soil's texture is the major factor affecting how much water it can hold for plant use. "Available water" refers to the amount of water that a soil can store and is accessible for plant use. Not all the water stored in the soil is available for the plant to use. Available water is the difference between field capacity (the most water the soil can hold) and permanent wilting point (soil water condition reached after the plants have taken all the water they possibly can from the soil - the soil is not completely dry, but plants are unable to take any more water from the soil).

A simple way to determine soil texture or soil type in the field can be done as follows:

> Place some soil in the palm of the hand. If the soil is dry, add a little water to the soil and gently rub the palms of the hands together. Use the guide on the following page for determining soil texture:

Soil cannot form a stick.		very sandy	Stick can be bent half-way round.		loam
Soil forms a stick. Will break when bent.		sandy	Stick can be bent more than half-way.		clay loam
Stick will bend a little before breaking.		sandy loam	Stick can be bent into a ring.		clay

DETERMINING SOIL TYPE

The following table shows the "available water" for the different soil textures:

SOIL TEXTURE	AVAILABLE WATER (INCHES/FOOT)
SANDY	0.5
SANDY LOAM	1.0
LOAM	1.6
CLAY LOAM	2.0
CLAY	1.8

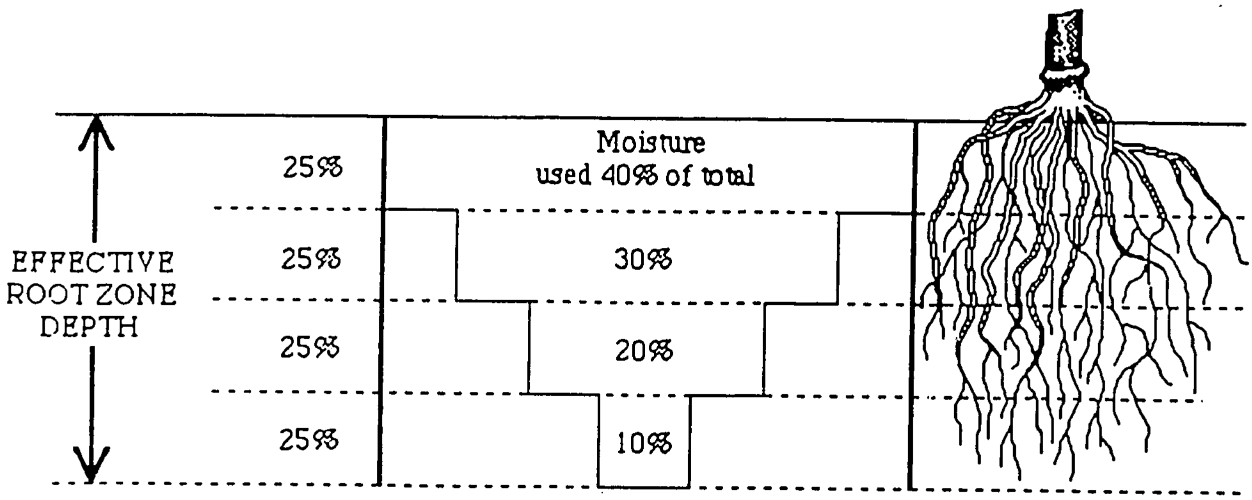
THE SOILS ON MUCH OF THE MORANT FARM ARE CLAY LOAM TO CLAY IN TEXTURE. THUS, THE AVAILABLE WATER TO THE PLANTS GROWN ON THE FARM IS ABOUT 2.0 INCHES PER FOOT OF SOIL. THERE IS ALSO SOME OF THE AREA THAT HAS VERY GRAVELLY, SANDY SOILS WHICH HOLD ONLY 0.5 INCHES OF AVAILABLE WATER PER FOOT OF SOIL.

PLANTS

The roots of the plants are in contact with the soil and feed the plants with water and nutrients as available in the soil.

Root depths vary by crops. **BANANAS, THE CROP GROWN ON THE MORANT FARMS, ITS ROOTS WILL PENETRATE TO A DEPTH OF APPROXIMATELY 3 FEET.**

The plant roots are not distributed equally throughout the soil. Most are near the soil surface. The distribution of the plant roots as found in the soil is approximately as shown in the figure on the following page. About 70% of all the plant roots are located in the top half of the root zone. Accordingly, the plant takes 70% of its water and nutrients needs from its top half of the root zone.



PLANT ROOT DISTRIBUTION IN THE SOIL

DEPTH OF IRRIGATION

In applying irrigation water, the goal is to fill the soil with water in the entire root area and no more. Even though 70% of the water is taken by the plant from the top half of the effective root area, irrigation water should still be applied throughout the entire plant root depth. As water is applied to the soil, the soil surface area takes the water first and then the water gradually moves down deeper into the soil. The more irrigation water that is applied, the deeper the soil is wetted. The goal is to apply just enough irrigation water to fill the soil to the depth of the plant roots. Wetting the soil below the plant root area is not beneficial unless it is necessary at times to move salts out of the root zone area. The downward movement of water below the plant roots has several disadvantages such as carrying plant nutrients beyond where the plants can use them, water logging the soil, etc.

As indicated above, the banana roots penetrate the soil to a depth of approximately 3 feet. The goal for bananas then is to apply irrigation water until it has reached a depth of 3 feet.

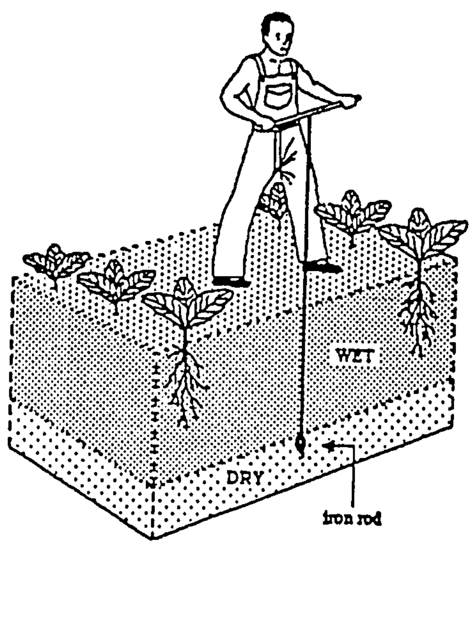
A way to determine how deep the irrigation water has gone into the soil, an irrigator can use an iron rod. The iron rod is 3\8 inch in diameter, 4 feet in length, with an enlarged tip or end. In wet soil, the rod will push into the soil very easily. When the tip or end of the rod reaches dry soil, it will push harder. The point at which the rod begins to push harder is the line between the wet soil and dry soil.

For bananas, irrigation should be stopped when the soil is wetted about 12 to 18 inches before the water reaches the bottom depth of the plant roots or at a depth of about 18 to 24 inches. Stopping the irrigation at this point, there will be enough water in the already wetted soil for the water to continue moving down to the lower 12 to 18 inches of the plant roots, or 3 foot depth.

The iron rod can be used for every irrigation. Some irrigations may take only a few hours to fill the soil in the plant root zone area, while other irrigations in the same field may take more time. This can be easily determined using the iron rod.

However, there are limitations to using the iron rod. In gravelly or very course soils, where there are rocks present in the soil profile, it may not be possible to push the iron rod into the soil because of the rocks. The soil auger, used for taking soil samples as discussed above, may need to be used in such kinds of soils. Even the soil auger may be difficult to use in gravelly, course soils.

Using the iron rod is shown in the following figure:



USING THE IRON ROD

The iron rod is not commercially available. It can be easily made in a welding shop using 3/8 inch rod, welding a "T" on one end for the handle and welding a 1/2 inch ball bearing on the other end as the enlarged tip or end of the rod.

AVAILABLE WATER TO THE PLANT

Knowing the soil texture and crop rooting depth the following table can be used to determine the "available water" per foot of soil:

SOIL TEXTURE	PLANT ROOT DEPTH (INCHES)	AVAILABLE WATER FOR PLANT USE(INCH)
SANDY	12	0.5
	24	1.0
	36	1.5
	48	2.0
SANDY LOAM	12	1.0
	24	2.0
	36	3.0
	48	4.0
LOAM	12	1.5
	24	3.0
	36	4.5
	48	6.0
CLAY LOAM	12	2.0
	24	4.0
	36	6.0
	48	8.0
CLAY	12	1.8
	24	3.6
	36	5.4
	48	7.2

As indicated above, where bananas are grown as on the Morant Farms, the top 36 inches (3.0 feet) of root depth and soil is considered for determining the available water for the crop. **When approximately 50% of the available water has been depleted (used by the crop) from the root zone area, (36 inches of soil for bananas), irrigation should be scheduled.** For example, with a clay loam soil, one of the major soils on the Morant Farms, 6.0 inches of water is available to the banana plant in the 36 inches of soil. When 3.0 inches of water has been depleted (**6.0 x 0.50 = 3.0**), irrigation should be scheduled. If the banana plant uses 0.25 inches of water per day during the hot season, irrigations need to be scheduled about every 12 or so days (**3.0 / 0.25 = 12**).

In the sandy, gravelly soil, only 1.5 inches of water is available. When 0.75 inches has been depleted (**1.5 x 0.50 =**

0.75), it is time to irrigate. Again, at 0.25 inches of water use per day during the hot season, irrigations need to be scheduled every 3 days.

FEEL AND APPEARANCE METHOD FOR DETERMINING AVAILABLE WATER

Available water in the soil can be approximated by feeling and by observing the appearance of the soil. This practice should be followed to be assured that the soil never becomes to dry before the next irrigation is scheduled. The irrigator needs to have a soil auger to "pull" soil samples from different depths in the soil to feel it and determine available water remaining for plant use. Using the feel and appearance method to estimate the available water for a clay loam soil and a sandy, gravelly soil as found on the Morant Farms is illustrated in the following pages. Also, a more detailed chart for using the feel and appearance method for estimating the available water is attached following the illustration pages.

For bananas, take soil samples to a depth of 12 to 18 inches throughout the field. For a clay loam soil, when squeezing and feeling the soil samples and samples are about to become crumbly (illustrated on the following page), but still will form a "ball" with pressure using the palm of the hand, the soil is approaching 50% available water depletion in the plant root area. Then irrigation should begin.

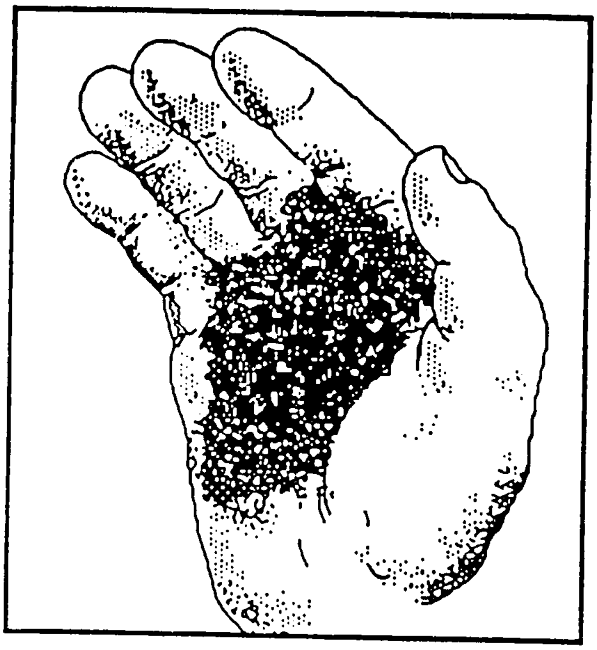
For the sandy soils, 50% of the available water has been depleted in the banana root zone are when the soil samples from the 12 to 18 inches actually feel and look dry and will not form a "ball" with pressure using the palm of the hand.

SOIL MOISTURE INSTRUMENTS

Technology is available today where instruments such as tensiometers and gypsum blocks can be installed in the soil which indicate when irrigations should begin. **HOWEVER, THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THE FEEL AND APPEARANCE METHOD ALWAYS BE USED TO ESTIMATE AVAILABLE WATER EVEN WHERE SOIL MOISTURE INSTRUMENTS ARE USED. USING THE FEEL AND APPEARANCE METHOD, THE IRRIGATOR WILL BE REQUIRED TO WALK THE FIELDS RESULTING IN BECOMING VISUALLY BETTER ACQUAINTED WITH THE CROP AND SOIL CONDITIONS. THIS IS MOST IMPORTANT IN IRRIGATION MANAGEMENT ON A FARM.**

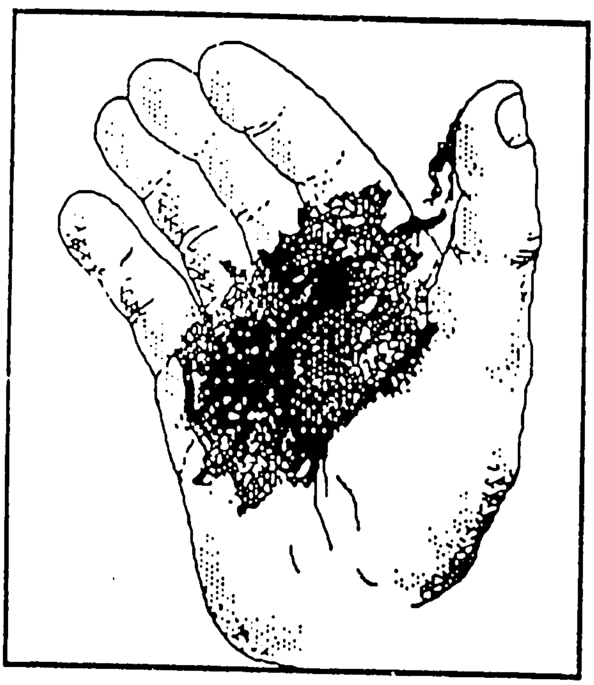
CROP CONSUMPTIVE WATER USE REQUIREMENTS

The crop consumptive water use requirement is the water use of any specified well-watered crop under optimum growing conditions. Crop consumptive use is usually considered the maximum water use of a crop for the given conditions. A study made on the Eastern

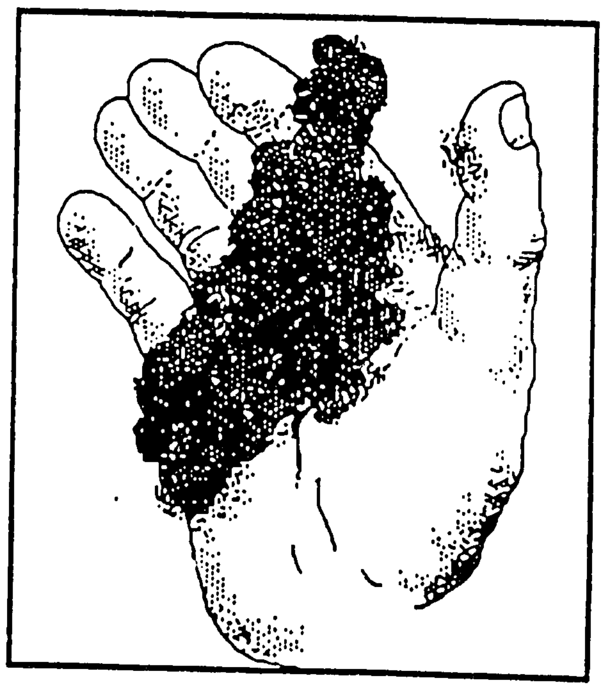


* 0 to 25% Available Moisture - Crumbles readily, "balls" with difficulty and breaks easily.

* 25 to 50% Available Moisture - Does not crumble, easily, forms readily, will "ball" with pressure.

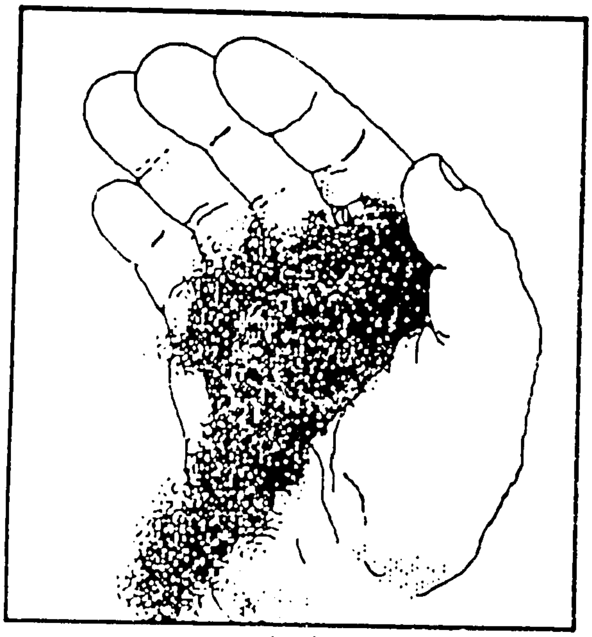


* 50 to 75% Available Moisture - Forms "ball" readily, will "ribbon" out between thumb and forefinger. Somewhat slick feeling.



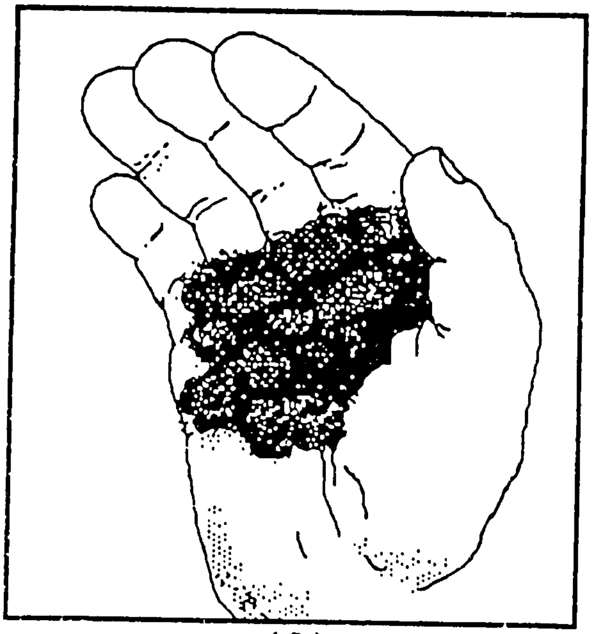
* 75 to 100% Available Moisture - Easily "ribbons" out. Has slick feeling.

USING THE FEEL AND APPEARANCE METHOD FOR FINE TEXTURED SOILS CLAY LOAMS AND SILTY CLAY LOAMS TO ESTIMATED AVAILABLE WATER



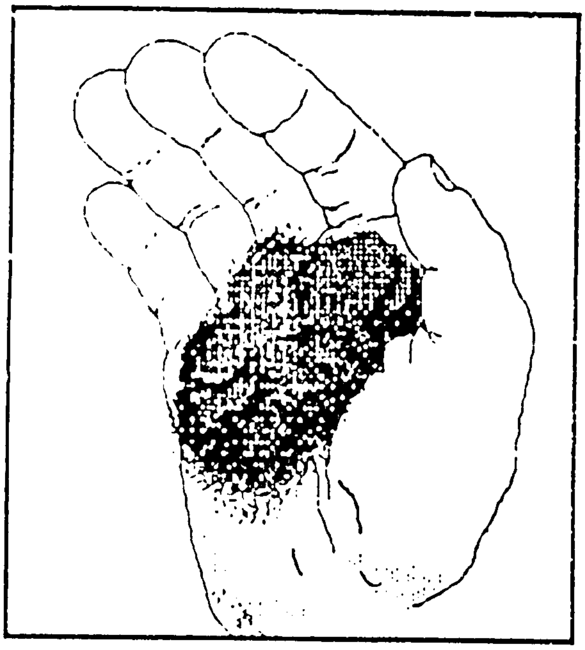
(1)

* 0 to 25% Available Moisture - Dry, loose, flows through fingers.



(2)

* 25 to 50% Available Moisture - Looks dry, will not form ball with pressure.



(3)

* 50 to 75% Available Moisture - Will form loose ball under pressure, will not hold together even with easy handling.

(4)

* 75 to 100% Available Moisture - Forms weak ball, breaks easily, will not "stick".

USING THE FEEL AND APPEARANCE METHOD FOR COURSE TEXTURED SOILS
SANDY LOAMS AND LOAMY SANDS
TO ESTIMATE AVAILABLE WATER

FEEL AND APPEARANCE CHART FOR AVAILABLE MOISTURE IN THE ROOT ZONE

Percentage of Soil Moisture Remaining	Soil Texture [Sands] (Loamy Sandy)	 [Sandy Loams] (Fine Sandy Loams)	 [Loams and Silt Loams] (Clay Loams)	 [Silty Clays] (Clays)
0 to 25%	Dry, loose soil flows through fingers [0 to 0.20] (0 to 0.25)	Dry, loose soil flows through fingers [0 to 0.40] (0 to 0.50)	Powdery, dry, crusty [0 to 0.55] (0 to 0.55)	Hard, cracked [0 to 0.50] (0 to 0.50)
25 to 50%	Appears dry, will not form a ball with pressure. [0.20 to 0.40] (0.25 to 0.50)	Appears dry, forms very weak ball under pressure [0.40 to 0.75] (0.50 to 1.00)	Partly crumbly, forms ball under pressure [0.55 to 1.10] (0.55 to 1.10)	Partly pliable, forms good ball under pressure [0.50 to 0.95] (0.50 to 0.95)
50 to 75%	Appears dry, forms very weak ball under pressure [0.40 to 0.60] (0.50 to 0.75)	Almost dry, tends to form a crumbly ball under pressure [0.75 to 1.10] (1.00 to 1.50)	Forms partly plastic ball, may slick with pressure [1.10 to 1.65] (1.10 to 1.65)	Forms ball and will ribbon [0.95 to 1.45] (0.95 to 1.45)
75 to 100%	Tends to stick, forms weak crumbly ball [0.60 to 0.80] (0.75 to 1.00)	Forms weak ball, will not stick [1.10 to 1.50] (1.50 to 2.00)	Forms very pliable ball and may stick [1.65 to 2.20] (1.65 to 2.20)	Easily ribbons and has slick feeling [1.45 to 1.90] (1.45 to 1.90)
100%	The soil is at field capacity. Upon squeezing, no free water appears on the soil, but a wet outline of the ball is left in the hand.			

NOTE: Figures in each parentheses show inches of water available moisture remaining per foot of depth.

Banana Estates, LTD., located a short distance from the Morant Farms, data indicates a daily consumptive us rate will vary between 0.15 to 0.25 inches of water per day for a banana crop (from cool season to hot season).

This same study on the Eastern Banana Estates, shows the mean rainfall for that area as follows:

MEAN RAINFALL (INCHES) BY MONTHS												
J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
4.0	3.3	2.3	3.4	9.3	6.9	4.6	6.3	8.5	11.9	9.2	5.8	75.5

The Morant Farms workers say that the Farms receives some less rainfall than Eastern Banana Estates. The workers indicated that Morant Farms receives 65 to 70 inches of rainfall on an average. The consulting Irrigation Engineer has made some adjustments to the rainfall amounts for the Morant Farms for irrigation scheduling purposes.

Considering the banana crop uses 0.25 inches of water per day during the hot season, during 30 day months the total water consumptive use totals 7.5 inches for the month (0.25 x 30 = 7.5) or 7.75 inches for a 31 day month. As one will note from the mean rainfall records above, there are several months where rainfall exceeds the banana water consumption. However, not all the rainfall is effective or enters the soil primarily because the rainfall comes at such high intensities that not all the rain water enters the soil. As an example, the records indicate that during the month of May with a mean rainfall of 9.3 inches, only 4.1 inches are considered as effective rainfall.

Considering the average effective rainfall, the mean consumptive irrigation requirements by months for bananas on the Morant Farms are as follows (consumptive water use requirement of a crop minus effective rainfall):

MONTH	IRRIG.REQ MEAN DEFICIT-NET (INCHES/ACRE)	IRRIG.REQ. VOLUME GUN (65% EFF.)	IRRIG. REQ. UNDER CANOPY (85% EFF.)
January	2.6	4.0	3.1
February	2.6	4.0	3.1
March	4.5	6.9	5.3
April	4.5	6.9	5.3
May	2.1	3.2	2.4
June	2.4	3.7	2.8
July	3.5	5.4	4.1
August	2.4	3.7	2.8
September	0.9	1.4	1.1
October	0.6	0.9	0.7
November	1.0	1.5	1.2
December	1.6	2.5	1.9

The above table shows the gross amount of water in inches that has to be pumped on the Morant Farms for each month by the irrigation systems to meet the monthly mean deficit or net irrigation requirements for the banana crop. The Morant Farms overhead high pressure volume gun sprinkler system has approximately a 65% water application efficiency because of resulting wind drift, evaporation, etc. The under canopy Morant Farms medium pressure sprinkler has a much more efficient water application than the high pressure volume gun system because the sprinklers are located under the banana canopy essentially eliminating wind drift, evaporation, etc. The under canopy sprinkler system has a water application efficiency of approximately 85%. Because of the difference in water application efficiency between the two sprinkler system, higher amounts of water need to be pumped by the volume gun system in comparison to the under canopy sprinklers to meet the net irrigation water requirements as shown in the above table.

WATER APPLICATION SCHEDULING

WATER PUMPING REQUIREMENTS
(INCHES/ACRE BY MONTHS)

MONTH	FOR 77.6 ACRES @65% APP.EFF.	FOR 12 ACRES @85% APP.EFF.	FOR 48.7 ACRES @85% APP.EFF.
January	310.4	36.7	149.0
February	310.4	36.7	149.0
March	535.4	63.5	257.8
April	535.4	63.5	257.8
May	248.3	29.6	120.3
June	287.1	33.8	137.5
July	419.0	49.4	200.5
August	287.1	33.8	137.5
September	108.6	12.7	51.2
October	69.8	8.5	34.1
November	116.4	14.1	57.3
December	194.0	22.5	91.7

Morant Farms Sprinkler Systems

The Morant Farms high pressure volume gun sprinkler system is used for irrigating 77.6 acres of land of which is mostly a clay textured soil. There is a small area of gravelly (sandy-rocky) type of soil. The clay soil has an available water holding capacity of 1.8 inches per foot of soil. The gravelly soil has a water holding capacity of 0.5 inches per foot of soil.

Two volume gun sprinklers are operated at the same time, each delivering 330 gallons/minute (as indicated earlier in this report, the pump is discharging 660 gallons/minute). **THE VOLUME GUN SPRINKLERS ARE SPACED 175 FEET BY 175 FEET. AT 660 GPM, THE TWO SPRINKLERS ARE APPLYING A GROSS WATER APPLICATION OF 1.5 INCHES PER HOUR (660 / 450 = 1.5).**

> **450 gallons/minute = 1 inch of water on 1 acre in 1 hour = 1 acre-inch per hour.**

At a 65% water application efficiency (discussed above), **A NET WATER APPLICATION INTO THE SOIL AND CROP ROOT AREA IS 1.0 INCH/HOUR** (1.5 x 0.65 = 1.0) by the two volume gun sprinklers.

As indicated above, for the under canopy sprinkler systems both for the 12 acres and the 48.7 acres on the Morant Farms, flow data could not be obtained during the field analysis due to water leaks in the pipelines. The under canopy sprinklers are spaced 46 feet by 46 feet. Assuming the sprinklers would operate at 40 psi, the discharge per nozzle would be 3.6 gallons per minute (from earlier table, above). The irrigation system is designed to operate 160 sprinklers. If each sprinkler is discharging 3.6 gallons per minute then the operating flow is 576 gpm. **WITH THE UNDER CANOPY SPRINKLERS SPACED 46 FEET BY 46 FEET AND A FLOW RATE OF 3.6 GPM/SPRINKLER NOZZLE, THE GROSS WATER APPLICATION RATE IS 1.28 INCHES/ HOUR.**

At an 85% water application efficiency (discussed above), **A NET WATER APPLICATION INTO THE SOIL AND CROP ROOT AREA IS 1.1 INCHES/HOUR** (1.28 x 0.85 = 1.1) for the 160 sprinklers.

HOURS PER MONTH SPRINKLERS MUST OPERATE

MONTH	VOLUME GUN FOR 77.6 AC.		UNDER CANOPY FOR 12 AC.		UNDER CANOPY FOR 48.7 AC.	
	(AC.-IN.)	(HRS.)	(AC.-IN.)	(HRS.)	(AC.-IN.)	(HRS)
January	310.4	207	36.7	29	149.0	116
February	310.4	207	36.7	29	149.0	116
March	535.4	357	63.5	50	257.8	201
April	535.4	357	63.5	50	257.8	201
May	248.3	166	29.7	23	120.3	94
June	287.1	191	33.8	26	137.5	107
July	419.0	279	49.4	38	200.5	157
August	287.1	191	33.8	26	137.5	107
September	108.6	72	12.7	10	51.2	40
October	69.8	47	8.5	7	31.4	27
November	116.4	78	14.1	11	57.3	45
December	194.0	129	22.5	18	91.7	72

Hours in a 30 day month = 720
Hours in a 31 day month = 744

OPERATING AND MAINTAINING THE IRRIGATION SYSTEM

* The major problem on the Morant Farms at this time is water leaks in the pipelines. It is very important that an irrigation system be properly maintained for efficient and adequate water application. On the Morant Farms, on the high pressure volume gun sprinkler system, numerous above ground water leaks were noted. The "O" rings gaskets in the above ground aluminum pipe need to be replaced in many of the pipe joints. A supply of the "O" rings should always be on hand. These gaskets are relatively inexpensive.

* Also, several mainline, underground pipe leaks were noted which need to be repaired.

* A number of valves, where the volume gun sprinklers are placed on the riser pipe, are also leaking. Again, these are rubber or plastic gaskets that can be easily replaced. A supply of these gaskets should also be available on the farm.

* Many of the pipeline valves are also leaking. The valves will need to be replace.

* The under canopy medium pressure sprinkler system has many water leaks in the underground pvc pipes. Sufficient water or pressure is just not getting to the sprinkler heads for adequate and efficient irrigation. The riser pipes were not adequately designed for the pressure required for the irrigation system. The risers and "T" couplers have broken in numerous places throughout the system. During the consulting Irrigation Engineer's visit, Morant Farms employed a contractor to repair the leaks throughout the irrigation system pipelines.

* Also, the sprinkler head risers must be as nearly horizontal as possible. If the risers are leaning, the water application by the sprinkler is very inefficient. It was observed that many of the sprinkler risers on the under canopy irrigation system are leaning.

* To easily detect irrigation system problems, a pipeline water flow meter and a pressure gauge should be installed near the discharge side of the irrigation pump. Weekly water flow meter, pressure and watt-hour readings should be taken. Any changes in these readings indicate changes in the condition of the irrigation system. Inspections are then required to locate the

problems in the irrigation system, equipment and/or pumping plant.

* It is recommended that the Morant Farms purchase a couple of nozzle pressure gauges to measure pressure at the sprinkler nozzle. As indicated above, weekly nozzle pressures should be taken. A change in nozzle pressure is an indication that a problem has developed.

* Permanent pressure gauges should be installed on all the high pressure volume gun sprinklers to monitor the pressure at these nozzles.

* A couple of soil augers should also be available for periodic field checking of the available soil moisture. Also, a couple of iron rods should be made for monitoring the depth of irrigations. The above irrigation schedules are a guide. Continual "feeling of the soil" using the soil auger and checking depth of irrigation using the iron rod should be part of the irrigation management on the farm.

* A pipeline water flow meter should be installed at the #3 pump discharge to monitor pump discharge as indicated above.

* Three or four rain gauges should be located throughout the farm to begin accumulating rainfall data.

* When operating the volume gun sprinklers, to keep the pressure somewhat equal to each of the sprinklers, when possible, locate one sprinkler near the pump area and the other at the farther distance from the pump.

* For the under canopy sprinklers, operate a portion of the sprinklers nearest the pump and another group of them farther from the pump. Again, this is to keep the pressure somewhat equal to all sprinklers.

AVAILABLE REPLACEMENT IRRIGATION EQUIPMENT AND SUPPLIES IN THE COUNTRY

The consulting Irrigation Engineer visited with the following Jamaican irrigation equipment dealers and suppliers:

* Caribbean Industrial Equipment - Kingston

* Ladimar Irrigation - Kingston

* Pumps and Irrigation - Kingston

* Jamaica Drip Irrigation - Mandeville

All the above dealers and suppliers indicated that they carry a large inventory of irrigation replacement supplies for both drip and sprinkler irrigation systems and for irrigation pumping plants. If one dealer or supplier does not have the replacement parts required for the irrigation system in use by the irrigator, one of the others may have it available.

AN IRRIGATION SCHEDULE FOR THE MORANT FARMS #1 PUMPING IRRIGATION SYSTEM

The #1 pumping plant serves a total of 89.6 acres of land, 77.6 acres are irrigated by high pressure overhead volume gun sprinklers and 12 acres are irrigated by medium pressure under canopy solid set (underground pvc piping) sprinklers. The soil texture on about 70 acres is clay loam to clay and on the remaining acreage (19.6 acres) the soil texture is rocky - gravelly - sandy. The crop grown is banana, depleting the soil water at an average rate of 0.25 inches/day.

The clay soils have 3.0 inches of available water at 50% depletion in the 3 foot root zone of bananas (above discussions). At a daily consumptive use rate of 0.25 inches, the irrigation interval for clay soils can be as high as 12 days.

The rocky - gravelly - sandy soils have 0.75 inches of available water at 50% depletion in the 3 foot root zone of bananas (again, above discussions). At a daily consumptive use rate of 0.25 inches, the irrigation interval is only about 3 days.

However, effective rainfall in combination with the daily consumptive water use rate must be considered for determining the monthly irrigation scheduling program.

THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THAT FOR THE CLAY SOILS, IRRIGATIONS BE SCHEDULED ON 10 DAY INTERVALS WITH 3 IRRIGATIONS PER MONTH DURING MOST OF THE MONTHS. FOR THE ROCKY - GRAVELLY - SANDY SOILS, IRRIGATIONS BE SCHEDULED ON 3 DAY INTERVALS WITH 9 TO 10 IRRIGATIONS PER MONTH.

Taking into consideration the soil textures, available soil water, monthly irrigation deficiency (effective rainfall and monthly crop water requirements), pumping flows, irrigation systems and irrigation system water application efficiencies, the following monthly irrigation schedule for the 89.6 land area - pumping plant #1, has been developed as follows:

MONTH	IRRIGATION OPERATION PLAN BY MONTHS

CODE

HPVGS = High pressure volume gun sprinklers
UCS = Under canopy sprinklers

January: HPVGS - clay soil area: irrigate 3 **times** during the month (every 10 days) - operate each set (two HPVGS/set) **1 hour/irrigation** applying 1.0 net inches/acre/irrigation.

HPVGS - gravelly soil area: irrigate 6 **times** during the month (every 5 days) - operate each set (two HPVGS/set) **30 minutes/irrigation** applying 0.5 net inches/acre/irrigation.

UCS - clay soil area: irrigate 3 **times** during the month (every 10 days) - operate the system for **10 hours/irrigation** applying 0.9 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 3.0 INCHES/ACRE.

February: HPVGS - clay soil area: irrigate 3 **times** during the month (every 9 days) - operate each set (two HPVGS/set) **1 hour/irrigation** applying 1.0 net inches/acre/irrigation.

HPVGS - gravelly soil area: irrigate 6 **times** during the month (every 4 to 5 days) - operate each set (two HPVGS/set) **30 minutes/irrigation** applying 0.5 net inches/acre/irrigation.

UCS - clay soil area: irrigate 3 **times** during the month (every 9 days) - operate the system for **10 hours/irrigation** applying 0.9 net inches/acre/ irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 3.0 INCHES/ACRE.

March: HPVGS - clay soil area: irrigate 3 **times** during the month (every 10 days) - operate each set (two HPVGS/set) **1.5 hours/irrigation** applying 1.5 net inches/acre/irrigation.

HPVGS - gravelly soil area: irrigate 9 **times** during the month (every 3 to 4 days) - operate each set (two HPVGS/set) **30 minutes/irrigation** applying 0.5 inches/acre/irrigation.

UCS - clay soil area: irrigate 3 **times** during the month (every 10 days) - operate the system for **17 hours/irrigation** applying 1.5 inches/acre/irrigation

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 4.5 INCHES/ACRE.

April: HPVGS - clay soil area: irrigate **3 times** during the month (every 10 days) - operated each set (two HPVGS/set) **1.5 hours/irrigation** applying 1.5 inches/acre/ irrigation.

HPVGS - gravelly soil area: irrigate **9 times** during the month (every 3 to 4 days) - operate each set (two HPVGS/set) **30 minutes/irrigation** applying 0.5 inches/ acre/irrigation.

USC - clay soil area: irrigate **3 times** during the month (every 10 days) - operate the system for **17 hours/ irrigation** applying 1.5 inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 4.5 INCHES/ACRE.

May: HPVGS - clay soil area: irrigate **3 times** during the month (every 10 days) - operate each set (two HPVGS/set) 45 **minutes/irrigation** applying 0.7 inches/acre/ irrigation.

HPVGS - gravelly soil area: irrigate **6 times** during the month (every 5 days) - operate each set (two HPVGS/set) 20 **minutes/irrigation** applying 0.35 inches/acre/ irrigation.

UCS - clay soil area: irrigate **3 times** during the month (every 10 days) - operate the system for 8 **hours/ irrigation** applying 0.7 inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 2.1 INCHES/ACRE.

June: HPVGS - clay soil area: irrigate **3 times** during the month (every 10 days) - operate each set (two HPVGS/set) **45 minutes/irrigation** applying 0.7 inches/acre/ irrigation.

HPVGS - gravelly soil area: irrigate **6 times** during the month (every 5 days) - operate each set (two HPVGS/set) 20 **minutes/irrigation** applying 0.35 inches/acre/ irrigation.

USC - clay soil area: irrigate **3 times** during the month (every 10 days) - operate the system for 8 **hours/ irrigation** applying 0.7 inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 2.1 INCHES/ACRE.

July: HPVGS - clay soil area: irrigate 3 **times** during the month (every 10 days) - operate each set (two HPVGS/set) **1 hour 15 minutes/irrigation** applying 1.2 inches/acre/irrigation.

HPVGS - gravelly soil area: irrigate **9 times** during the month (every 3 to 4 days) - operate each set (two HPVGS/set) 25 **minutes/irrigation** applying 0.4 inches/acre/irrigation.

UCS - clay soil area: irrigate 3 **times** during the month (every 10 days) - operate the system for 13 **hours/irrigation** applying 1.2 inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 3.6 INCHES/ACRE.

August: HPVGS - clay soil area: irrigate 3 **times** during the month (every 10 days) - operate each set (two HPVGS/set) 45 **minutes/irrigation** applying 0.7 inches/acre/ irrigation.

HPVGS - gravelly soil area: irrigate 6 **times** during the month (every 5 days) - operate each set (two HPVGS/set) 25 **minutes/irrigation** applying 0.35 inches/acre/irrigation.

UCS - clay soil area: irrigate 3 **times** during the month (every 10 days) - operate the system for 9 **hours/irrigation** applying 0.7 inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 2.1 INCHES/ACRE.

September: HPVGS - clay soil area: irrigate **once** during the month operating each set (two HPVGS/set) 1 **hour** applying 1.0 inches/acre for the one irrigation.

HPVGS - gravelly soil area: irrigate 2 **times** during the month (every 15 days) - operate each set (two HPVGS/set) 30 **minutes/irrigation** applying 0.5 inches/acre/irrigation.

USC - clay soil area: irrigate **once** during the month operating the system for 10 **hours** applying 0.9 inches/acre for the one irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 1.0 INCHES/ACRE.

October: HPVGS - clay soil area: irrigate **once** during the month operating each set (two HPVGS/set) **35 minutes** applying 0.6 inches/acre for the one irrigation.

HPVGS - gravelly soil area: irrigate **2 times** during the month (every 15 days) - operate each set (two HPVGS/set) 20 **minutes/irrigation** applying 0.3 inches/acre/irrigation.

UCS - clay soil area: irrigate **once** during the month operating the system for 7 **hours** applying 0.6 inches/acre for the one irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 0.6 INCHES/ACRE.

November HPVGS - clay soil area: irrigate **once** during the month operating each set (two HPVGS/set) **1 hour** applying 1.0 inches/acre for the one irrigation.

HPVGS - gravelly soil area: irrigate **2 times** during the month (every 15 days) - operate each set (two HPVGS/set) 30 **minutes/irrigation** applying 0.5 inches/acre/irrigation.

USC - clay soil area: irrigate **once** during the month operating the system **11 hours** applying 1.0 inches/acre for the one irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 1.0 INCHES/ACRE.

December: HPVGS - clay soil area: irrigate **2 times** during the month (every 15 days) - operate each set (two HPVGS/set) 35 **minutes/irrigation** applying 0.7 inches/acre/irrigation.

HPVGS - gravelly soil area: irrigate **4 time** during the month (every 7 to 8 days) - operate each set (two HPVGS/set) **30 minutes/irrigation** applying 0.4 inches/acre/irrigation.

UCS - clay soil area: irrigate **2 times** during the month (every 15 days) operating the system **9 hours/irrigation** applying 0.7 inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 1.4 INCHES/ACRE.

As indicated, the above irrigation schedules are based on mean rainfall and mean effective rainfall. If average or means do not happen, irrigation requirements will vary from those used above. The above is a guide. Thus, it is so very important to continuously "pull" soil samples to more accurately determine when irrigations are required. Also, use the iron rod during every irrigation to make sure the irrigation times are right.

OPERATING TIME FOR THE #1 PUMP IRRIGATION SYSTEM

MONTH	HOURS SYSTEM REQUIRED TO OPERATE/MONTH	HOURS SYSTEM TO OPERATE/DAY 5 DAY WEEK	6 DAY WEEK	7 DAY WEEK
January	236	12	10	9
February	236	12	10	9
March	407	21	17	15
April	407	21	17	15
May	189	10	8	7
June	217	11	9	8
July	317	16	13	11
August	217	11	9	8
September	82	4		
October	54	3		
November	89	5		
December	147	8	6	

Alternatives To Reducing The Hours/Day The Irrigation System Must Operate During The High Month Operating Times

1. Increase the pumping capacity of #1 pump. The motor is now drawing 41 horsepower. The motor size on #1 pump is a 75 horsepower. The load can be doubled with this size motor. Thus, increasing the pump capacity would be no problem. However, the 6 inch pvc mainline is not large enough to handle another 225 gallons/minute as required for adding one high pressure volume gun sprinkler. Increasing the mainline pipe from 6 inches to 8 inches would make this a viable alternative.

2. Replacing the high pressure volume gun sprinklers with medium pressure under canopy sprinklers would help reduce the hours some because of higher water application efficiencies with the under canopy sprinklers. Again, increasing the water flow using under canopy sprinklers by increasing the pump size and mainline pipe size would make this a viable alternative.

3. The immediate solution may be to have enough high pressure volume gun sprinklers available and having them in place by early evening that during the night the irrigator

would need only to open and close valves. This doesn't decrease the number of hours the system must operate but makes the system easier to operate during the night time hours.

4. Another alternative which may need to be considered is to provide incentive payments to the irrigation worker who works during the night time hours or during holidays.

AN IRRIGATION SCHEDULING PLAN FOR MORANT FARMS #3 PUMPING IRRIGATION SYSTEM

The #3 pumping plant serves a total of 48.7 acres of land irrigated with medium pressure under canopy solid set sprinklers (underground pvc piping). The soil texture on most of the land is clay to clay loam to clay. The crop grown is banana, depleting the soil available water at an average of 0.25 inches/day.

The clay soils have 3.0 inches of available water at 50% depletion in the 3 foot root zone of bananas (above discussions). At a daily consumptive use rate of 0.25 inches, the irrigation interval for the clay soils can be as high as 12 days.

THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THAT FOR THE CLAY SOILS, IRRIGATIONS BE SCHEDULED ON 10 DAY INTERVALS WITH 3 IRRIGATIONS PER MONTH DURING MOST OF THE MONTHS.

Taking into consideration the soil textures, available soil water, monthly irrigation deficiency (effective rainfall and monthly crop water requirements), pumping flows, irrigation systems and irrigation water application efficiencies, the following monthly irrigation schedule for the 48.7 land area, has been developed:

January: Irrigate 3 times during the month (every 10 days), operating each set 7 **hours/irrigation** applying 0.9 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 2.7 INCHES/ACRE.

February: Irrigate 3 **times** during the month (every 9 days), operating each set 6 **hours/irrigation** applying 1.1 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 2.7 INCHES/ACRE.

March: Irrigate 3 **times** during the month (every 10 days), operating each set **11 hours/irrigation** applying 1.5 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 4.5 INCHES/ACRE.

April: Irrigate 3 **times** during the month (every 10 days), operating each set **11 hours/irrigation** applying 1.5 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 4.5 INCHES/ACRE.

May: Irrigate 3 **times** during **the** month (every 10 days), operating each set 5 **hours/irrigation** applying 0.7 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 2.1 INCHES/ACRE.

June: Irrigate 3 **times** during the month (every 10 days), operating each set 6 **hours/irrigation** applying 0.8 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 2.4 INCHES/ACRE.

July: Irrigate 3 time during the month (every 10 days), operating each set 9 **hours/irrigation** applying 1.2 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 3.6 INCHES/ACRE.

August: Irrigate 3 time during the month (every 10 days), operating each set 6 **hours/irrigation** applying 0.8 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 2.4 INCHES/ACRE.

September: Irrigate 1 **time** during the month, operating each set 7 **hours for the one irrigation** applying 0.9 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 0.9 INCHES/ACRE.

October: Irrigate 1 **time** during the month, operating each set 5 **hours for the one irrigation** applying 0.6 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 0.6 INCHES/ACRE.

November: Irrigate 1 **time** during the month, operating each set 8 **hours for the one irrigation** applying 1.0 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 1.0 INCHES/ACRE.

December: Irrigate 2 **times** during the month (every 15 days), operating each set 6 **hours/irrigation** applying 0.8 net inches/acre/irrigation.

TOTAL NET IRRIGATION WATER APPLIED FOR THE MONTH EQUALS 1.6 INCHES/ACRE.

As indicated, the above irrigation schedules are based on mean rainfall and mean effective rainfall. If average or means do not happen, irrigation requirements will vary from those used above. The above is a guide. Thus, it is so very important to continuously "pull" soil samples to more accurately determine when irrigations are required. Also, use the iron rod during every irrigation to make sure the irrigation times are right.

IRRIGATION SYSTEM READINGS

DATE	PUMP	WATT-HOUR	PUMP PRESS.	NOZZLE PRESS.	FLOW

VEGETABLE PRODUCTION ON THE MORANT FARMS

During several conversations with Morant Farms General Manager, Wayne Peart, and the consulting Irrigation Engineer, Wayne indicated that in the future the Morant Farms may be interested in developing new irrigated lands and producing vegetables crops. All the basic irrigation principles discussed earlier in this report apply to vegetable production. Irrigation water requirements during the flowering to maturity of the vegetable crop will be essentially the same as bananas.

Root depths vary with vegetable crops as follows:

12 TO 15 IN	15 TO 24 IN	24 TO 30 IN.	30 TO 40 IN
Lettuce	Cabbage	Carrots	Tomatoes
Radishes	Cauliflower	Eggplant	Asparagus
Spinach	Peas	Potatoes	Melons
Onions	Green beans	Cereal crops	Parsnips
Broccoli	Cucumbers	Cantaloupe	Turnips
Brussel Sprouts	Peppers	Groundnut	Pumpkins
Celery	Red Beets		Squash
Garlic	Swiss Chart		Sweet Potatoes
Strawberries			

Using earlier soil texture and available water tables in this report and the above crop root depths, the total water available can be calculated and an irrigation schedule developed for each vegetable crop.

The consulting Irrigation Engineer recommends that a Horticultural Specialist at the University of West Indies be consulted to inquire which vegetables crops can and can not be grown in the clay textured soils on the Morant Farm.

Also, another well will need to be put into production. Well #1 and #3 are now serving the maximum acres. These wells could serve more acres but more night time irrigations would be required to adequately irrigate the present acreage in addition to any new lands.

IRRIGATION SUPERVISOR JOB DESCRIPTION

Morant Farms General Manager, Wayne Peart, has developed a very adequate irrigation supervisor job description. The only recommendations the consulting Irrigation Engineer would add are that the irrigation supervisor have mechanical skills and have a very positive attitude towards agriculture (the love of growing plants). The following is the job description developed by Mr. Peart:

TITLE : IRRIGATION SUPERVISOR

GRADE :

DEPARTMENT : AGRICULTUREL

CORE FUNCTIONS

(1) Supervise the overall irrigation operation.

Educational Requirements ;

(1) Specific knowledge (however acquired) required to start.
(2) Knowlegde and experience in supervising an Irrigation system.
(3) Knowlegde of Agricultural practices.

Qualifications and Experience ;

(1) Cast Diploma in Engineering or its equivalent.
(2) At least five years experience at a Supervisory level of an Irrigation System.

Required Skills and Specialised Techniques ;

(1) Ability to solve Technical problems of an Irrigation System.
(2) Good leadership skills.
(3) Skills in using P.C. Packages.

Special Conditions Assiciated with Job ;

(1) Ability to function under pressure, which includes working irregular hours.
(2) Ability to work within severe time contrain~~ment~~s.
(3) Required to work overtime, whenever necessary.

Supervision Recieved From General Manager.

Supervision Given to ;
(1) DIRECTLY : Workers assigned
(2) INDIRECTLY : None

Liases With

(1) Internally : Field Supervisors

(2) Externally : Irrigation Associates

Responsibilities and Duties ;

(1) Supervise the Irrigation operation.
(2) Ensure that Pumps and Wells and surrounding are in good working condition.
(3) Ensure that the Irrigation System is operating effectively and efficiently.
(4) Supervising the Irrigation workers to ensure that the highest standard of work is achieved.
(5) Implementing General Manager decision expeditiouly.
(6) Providing weekly reports of the Irrigation System.
(7) Any other related activity.

Authority

(1) To make external contact with Irrigation Associates after consultation with General Manager.
(2) Stop worker from carrying out his or her job owing to valid reason.

PERFORMANCE CRITERIA

This Job is satisfactory performed when;

: Accurate reports are presented

: When Irrigation System is operating effectively and efficiently.

: When strong level of Leadership is demonstrated.

: When workers perform at a high standard.

IRRIGATION TRAINING

The consulting Irrigation Engineer worked with and provided training for the Morant Farms irrigation workers throughout the visits on the farm. The workers included Mr. Wayne Peart, General Manager; Mr. Neville Davidson, field supervisor; Mr. Grant Hibbert, irrigation supervisor; Mr. Lloyd Brown, field supervisor; Mr. Ephraim Carr, irrigation worker; Mr. Anthony Walcott, field supervisor; Mr. Alfred Johnson, irrigation worker; Mr. Garth Skeene, irrigation worker and Mr. Athony Mitchell, irrigation worker. The consulting Irrigation Engineer would rate the irrigation workers on the Morant Farms as very knowledgeable and capable for operating and managing the irrigation systems and irrigation pumping plants.

The University of West Indies will be conducting an irrigation short course on May 29 to June 9, 1995. The short course is entitled "Irrigation: Principles and Practices for Caribbean Agriculture". The consulting Irrigation Engineer visited with the short course coordinators. It was indicated that the short course will be geared for students with a High School Diploma and above. The consulting Irrigation Engineer recommends Morant Farms consider sending one of their irrigation workers to attend the irrigation short course.

IT IS RECOMMENDED BY THE CONSULTING IRRIGATION ENGINEER THAT ONE IRRIGATION WORKER BE DESIGNATED AND ASSIGNED THE RESPONSIBILITY FOR WALKING THE FIELDS DURING IRRIGATIONS, OBSERVING AND NOTING IRRIGATION SYSTEM PROBLEMS, BE RESPONSIBLE FOR TAKING SOIL MOISTURE SAMPLES AND RECORDING THE FINDINGS, USING THE IRON ROD TO DETERMINE DEPTHS OF IRRIGATIONS, RECORD PRESSURE GAUGE READINGS, RECORD PIPELINE WATER FLOW METER READINGS, RECORD WATT-HOUR METER READINGS AND OBSERVE CROP CONDITIONS. THIS INDIVIDUAL BE IN CONTINUAL COMMUNICATION WITH THE GENERAL FARM MANAGER AND FARM IRRIGATION SUPERVISOR TO INFORM SUCH ON SYSTEM PROBLEMS, MAINTENANCE REQUIREMENTS AND IRRIGATION WATER APPLICATION REQUIREMENTS AND CONDITIONS.

REVISIT TO THE MORANT FARM ON APRIL 8, 1995

The consulting Irrigation made another visit to the Morant Farms on April 8, 1995. Progress was being made by the contractor in repairing the water leaks under the pump #3 irrigation system. Not all water leaks had been repaired at the time. Pressure readings were taken at the sprinkler nozzles. The pressure has been increased to 40 psi compared to the 19 or so psi measured during the consulting Irrigation Engineer's earlier visit. This demonstrates the importance of keeping all pipe water leaks repaired. The flow of each sprinkler nozzle has been increased from 2 gpm to 3.6 gpm without any increase in the pumping capacity. All this water and pressure was being lost through leaks in the pipes. With 256 sprinklers operating at one time, this meant about 250 gpm of water was lost through the leaks in the pipe **(1.6 gpm/sprinkler x 160 sprinklers = 256 gpm).**

The question was asked whether drip irrigation could be part of the volume gun irrigation system. The thought is to install a drip irrigation system on the sandy - gravelly soils. A drip irrigation system can be installed using the same main line pipe that delivers the water to the volume guns. To reduce the pressure to the 10 to 15 psi required for the drip irrigation, use a globe valve and pressure gauge.

When sprinklers are operating at the manufacturer's recommended pressure, one can observe a "veil" of water falling to the ground as water is discharged from the sprinkler nozzle. When the sprinkler is operating at a pressure below the manufacturers recommended pressure, one will observe large drops of water all falling in one area giving a "donut" water application pattern. This holds true for the sprinklers such as the under canopy sprinkler as well as the volume gun sprinklers. It is very important that sprinklers be operated at the recommended pressures to provide uniform water application.

An irrigation schedule has been developed by the consulting Irrigation Engineer for the 47.8 acres, pump #3 irrigation system and included above.

BLOOMING THINGS FARM

ST. CATHERINE

BOG WALK, JAMAICA

IRRIGATION REPORT

MARCH 21 - 25, 27 - 28 AND APRIL 10, 1995

DONALD J. BROSZ
CONSULTING IRRIGATION ENGINEER

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT

CHEMONICS INTERNATIONAL CONSULTING DIVISION
WASHINGTON, D.C.

4/ä

BLOOMING THINGS FARM

ST. CATHERINE

BOG WALK, JAMAICA

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT IRRIGATION SCOPE OF WORK

* Meet with the owners and managers of Blooming Things, and other participating farms, to gain first-hand information on the steps which have been carried out to date regarding the installation of an irrigation system.

* Design an approach to the overall project which calls for involvement of selected trainees in the on-site project activities as a way to learning about and testing their capacities in field situations.

* With Blooming Things' selected group of trainees, conduct in-depth, on-site visits to get a first-hand picture of the status of the existing irrigation systems installation activity and make specific recommendations with regard to next steps. At the same time, inventory related equipment and determine level and type of maintenance support which would be required from an on-farm irrigation supervisor.

* If appropriate, supervise final irrigation installation and set up for Blooming Things and/or ensure that steps for final set up are in place and can be followed up from Jamaica.

* Provide back-up classroom training and exercises to test and augment the skills, as necessary, of candidates for the irrigation supervisor position. If the need for additional training is identified, work with SBED management to locate a suitable source to provide such training.

* Rate Blooming Thing' trainees in terms of their strengths. Assist management to develop a job description which meets the requirements of the farm, and participate in the final selection of an irrigation supervisor from among the trainees.

BLOOMING THINGS FARM IRRIGATION RECOMMENDATIONS

FARM IRRIGATION SYSTEM OPERATION, MANAGEMENT AND MAINTENANCE

* Replace present filter with larger filter to fit the quantity of water being pumped.

* Regularly flush the drip pipelines and clean plugged micro-jets of silt to provided uniform irrigation water application.

* Keep pipeline leaks repaired to provide uniform irrigation water application.

* Keep micro-jets in a vertical position and uniformly spaced to provide more uniform irrigation water application.

* Do not intermix drippers - replace damaged micro-jet with micro-jet heads, not with spinner heads and visa versa when new drip system is installed. This provides for more uniform irrigation water application.

* Spaghetti lines - small water lines connecting the micro-jets to the lateral line - should all be near uniform in length. The spaghetti line length determines the amount of water flow to the micro-jet.

* Replace plastic turn on - shut off valves on the drip irrigation system with brass valves.

* One irrigation worker be designated and assigned the responsibility for walking the fields during irrigations, observing and noting irrigation system problems, be responsible for taking soil moisture samples and recording the findings, using the iron rod to determine depths of irrigations, record pipeline water flow meter readings, record pressure readings and observe crop conditions. This individual be in continual communication with the General Farm Manager and Farm Irrigation Supervisor to inform such on system problems, maintenance requirements and irrigation water application requirements and conditions.

* Use the irrigation schedules as developed for the farm by the consulting Irrigation Engineer as a guide - supplement the guide by taking soil samples in the Gingers area, once irrigation system is installed, using the feel and appearance method to more accurately predict the times when irrigation water needs to be applied to each field and use the iron rod to more accurately determine when irrigations can be stopped.

* Provide the irrigation worker with irrigation equipment to carry out the required irrigation duties efficiently and effectively such as a soil auger, an iron rod, sprinkler nozzle pressure gauge and a supply of irrigation system replacement parts.

* When installing the new 6 acre drip irrigation, extend the present 10 acre delivery mainline to a portion of the 6 acre area and the new delivery mainline to the other portion of the 6 acre to provide alternatives in managing the irrigations in the entire 16 acres of Anthuriums.

* Once the sprinkler system has been installed in the Gingers area, consideration may be given to paying an incentive to an irrigation worker to guard the sprinklers from thievery during the times when it is necessary to leave the sprinkler heads in the field during the night time and/or holiday hours.

IRRIGATION MANAGEMENT INFORMATION

BLOOMING THINGS FARM

BOG WALK, JAMAICA

MARCH 21 - 25, 27 - 28 AND APRIL 10, 1995

IRRIGATION PUMPING PLANT

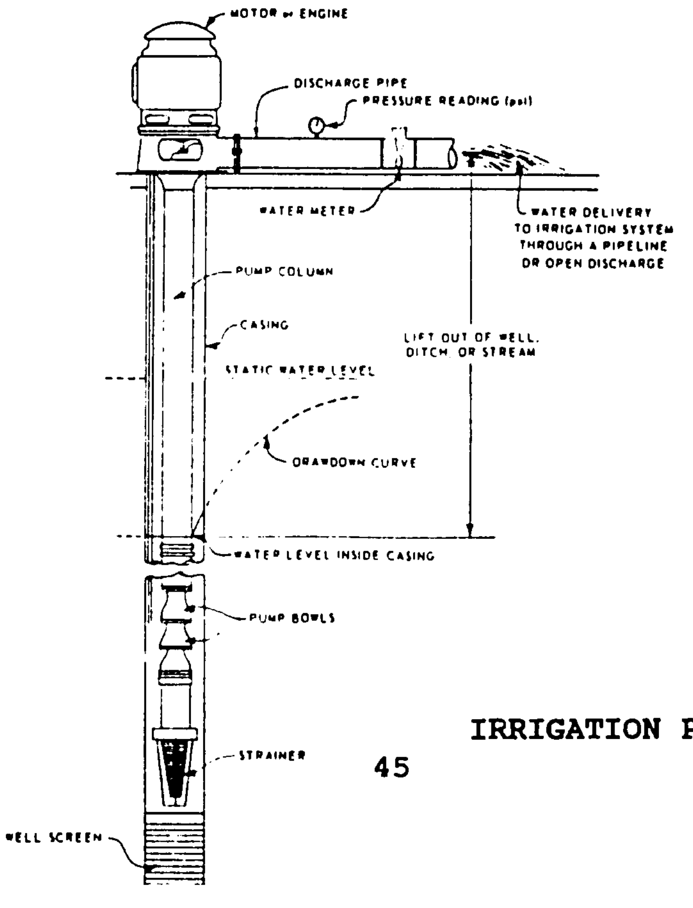
The energy costs for operating an irrigation pumping plant are a major cost to an irrigator. There are four factors that determine the power and energy requirements of an irrigation pumping plant. They are:

1. The quantity of water being pumped generally expressed as gallons per minute (gpm) when a irrigation pumping plant is in operation.

2. The depth from which water is lifted in the well to the discharge side of the pump (distance between the water surface while the pump is operating and discharge point at the pump).

3. The pressure at the discharge point of the pump when it is operating, as expressed in pounds per square inch (psi).

4. The efficiency of the irrigation pumping plant expressed in percent.



IRRIGATION PUMPING PLANT

The above figure shows a typical irrigation pumping plant in operation. This shows the power unit located at the surface (electric motor in this case). There are irrigation pumping plants where the electric motor is located in the well with the pump. This type of irrigation pumping plant is known as a submersible motor and pump. It operates exactly the same as the irrigation pumping plant shown in the above figure.

The distance water is lifted out of the well plus the pressure at the pump discharge (2 and 3 above) is expressed as total lift in feet (often referred to as total dynamic head - in this report it will be referred to as total lift). This lift is shown in the above irrigation pumping plant figure - the distance the water is lifted to the pump discharge, measured in feet - the pressure reading, measured in pounds per square inch (psi). Everything needs to be in feet. **TO CONVERT PSI TO FEET, MULTIPLY THE PSI READING BY 2.31.** For example, a pressure reading of 70 psi is equal to 162 feet (70 x 2.31 = 162). Adding the two, distance water is lifted out of the well in feet (this distance should be measured by the well driller upon completion of the well) plus the discharge pressure in feet, equals total lift in feet. There is a small additional loss in the pump column or suction side of the pump that should be added to the total lift. However, this generally is a relatively small amount and can be disregarded.

Efficiency of an irrigation pumping plant is an indicator as to the ability of the total irrigation pumping plant to deliver a quantity of water at a required total lift using the least amount of energy. No irrigation pumping plant is 100% efficient, not even a perfectly designed new irrigation pumping plant. Energy is lost within the electric motor or internal combustion engine because of operating characteristics (slippage, bearing friction, etc.). Power is also lost between the drive shaft and the pump. Energy is also lost in the pump because of its operating characteristics, friction in the well screen, etc. **A typical irrigation pumping plant, properly designed, will operate at approximately 66% efficiency (electric motor 88% and pump 75% = 0.88 x 0.75 = 0.66).** A more accurate irrigation pumping plant efficiency can be obtained from a pump performance curve available for every pump. An irrigator should request a copy of the pump performance curve from the dealer at the time of purchase of the pump and keep it in the irrigation system file for future reference.

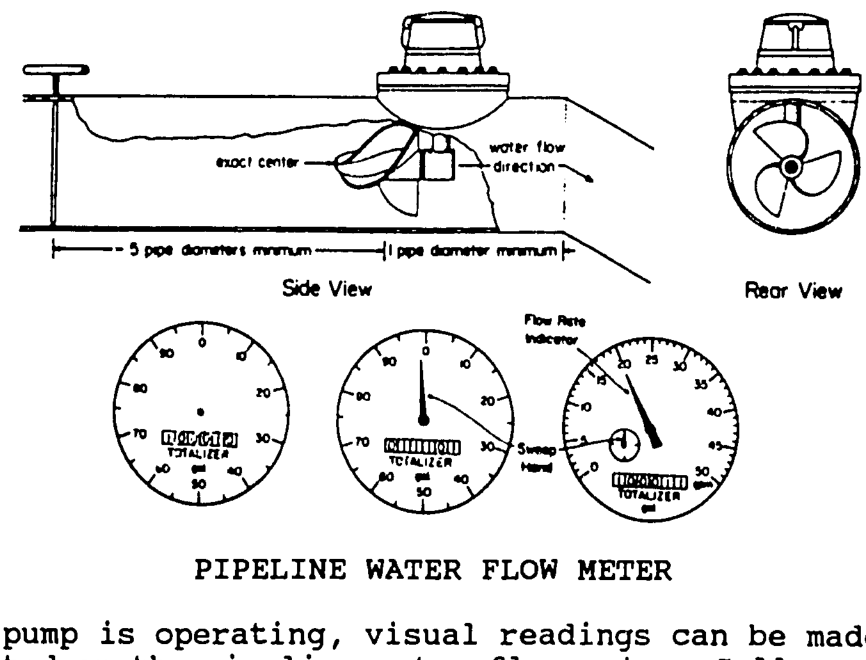
BLOOMING THINGS FARM IRRIGATION PUMPING PLANT

Blooming Things Farm is pumping water from a well. The irrigation pumping plant is a submersible motor and pump. The well is approximately 130 feet in depth, static water level at 38 feet and the submersible pump and motor located at a depth of 100 to 110 feet. The electricity for the submersible pump is supplied by a stationary diesel driven generating unit instead of electrical power supplied by the Jamaican Electric Utility. The Blooming Things General Farm Manager, Ms. Hilda Vaughan, indicated that the Jamaican Electric Utility electrical service has numerous power interruptions. Thus, the Utility power service is not reliable enough for planning and efficiently conducting the operations of the irrigation pumping plant.

The Blooming Things Farm submersible irrigation pump is powered by a 60 horsepower electric motor, operating at 2900 revolutions per minute (rpm).

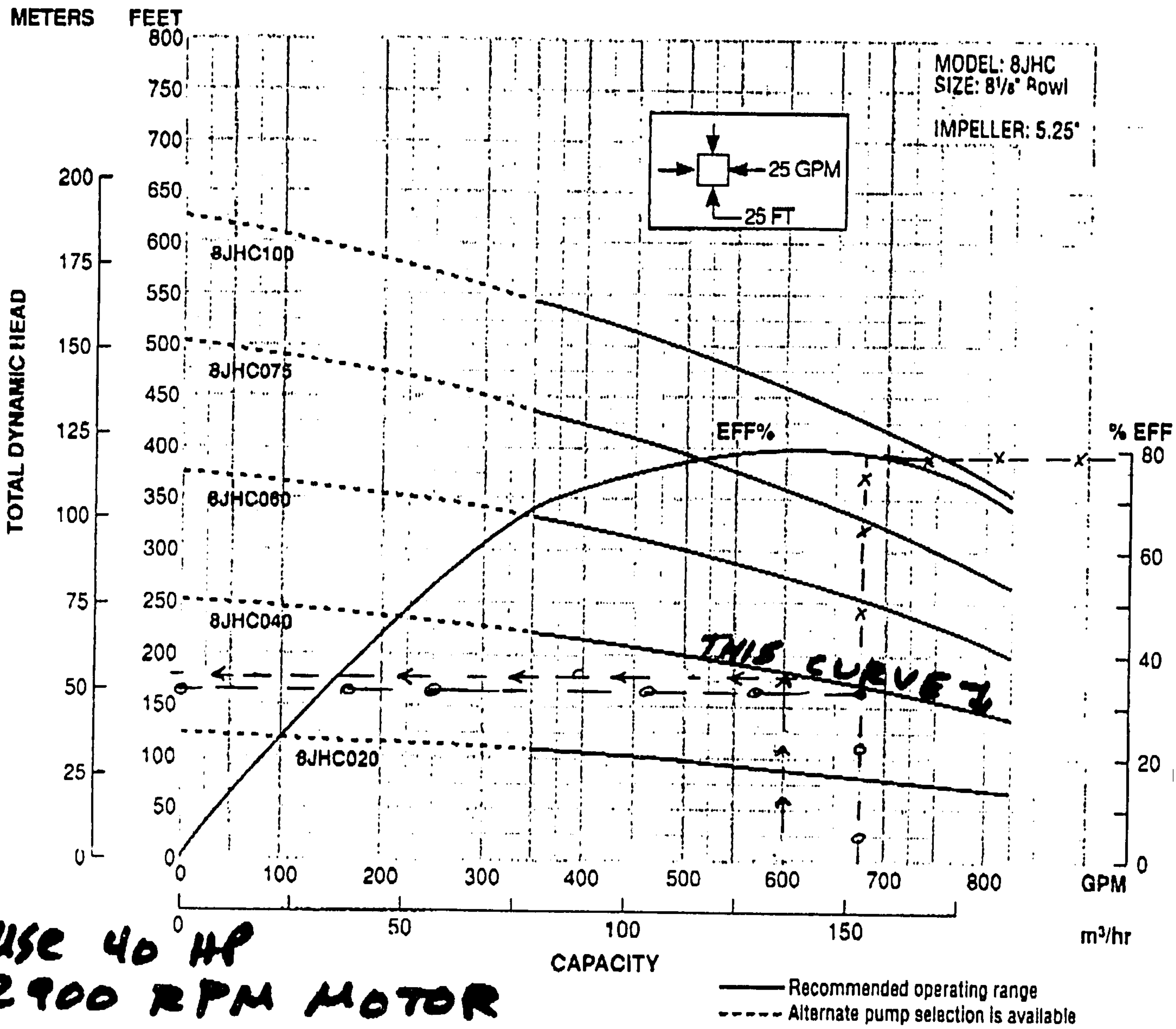
The turbine pump is a Goulds, Model 8JHC. According to the pump performance curve (attached, following page), the pump will deliver 600 gallons per minute (gpm) at a total lift of 180 feet (follow the arrows as drawn in by the consulting Irrigation Engineer).
To be more accurate for each specific irrigation pumping plant installation, a pipeline water flow meter should be installed near the pump discharge. A pipeline water flow meter provides an irrigator instantaneous readings of water being pumped. A water flow meter was installed on April 10, during the consulting Irrigation Engineer's return visit. Instead of the pump delivering 600 gpm as originally thought, the pump is delivering 680 gpm (approximately 15% more). Again, referring to the pump performance curve, the pump will pump 680 gpm with a total head of 160 feet (this time follow the "- - -o- - - o" on the performance curve).

A typical pipeline water flow meter is shown as follows:



PIPELINE WATER FLOW METER

While the pump is operating, visual readings can be made from the dials located on the pipeline water flow meter. Gallons per minute (gpm) being pumped at the time the irrigation pumping plant is in



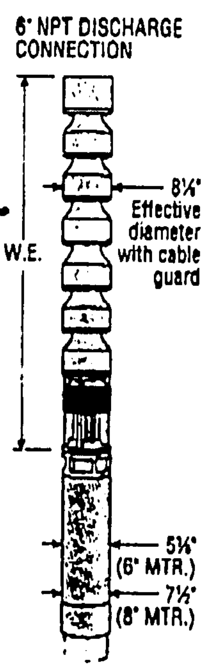
USE 40 HP
2900 RPM MOTOR

DIMENSIONS AND WEIGHTS

HP	Stages	W.E. Order Number	W.E. Length	W.E. Wt. (lbs.)
20	1	8JHC02066BTS	19	90
40	2	8JHC04066BTS	25¾	130
60	3	8JHC06066BTS	31¾	170
75	4	8JHC07586BTS	38¼	210
100	5	8JHC10086BTS	44½	250

(All dimensions in inches and weights in lbs. Do not use for construction purposes.)

PLEASE NOTE:
- Order motors separately.
- For intermediate horsepower pumps consult factory.
- Solid line is recommended operating range. The dotted line (----) signifies an alternate pump selection is available.
- Please specify all options changes in W.E. order number.



MATERIALS OF CONSTRUCTION

Part Name	Material
Shaft	ASTM A582 TYPE 416
Coupling	ASTM A582 S41600 CD
Suction Adapter	ASTM A48 CL 40
Discharge Bowl	ASTM A48 CL 30B
Rubber Bearings	RUBBER
Optional Bronze Bearings	ASTM B584
Discharge Bowl Bearing	ASTM B584
Taperlocks	ASTM A108 GR 1018
Epoxy Lined Bowl	ASTM A48 CL 30B
Upthrust Collar	ASTM A276 S41400
Impeller	ASTM B584
Fasteners	SAEJ429 GR 8
Cable Guard	ASTM A240 S 30400
Suction Strainer	ASTM A240 S 30400

operation can be read. Also, total quantity of water pumped in gallons over a period of time, can be read **(326,000 gallons equal 1 acre-foot of water which is equal to 12 inches of water on one acre or 1 inch of water on 12 acres).** The Blooming Things pipeline water flow meter gpm and total quantity of water pumped readings are taken electronically and displayed on a control panel instead of dials as shown above.

A couple of pressure gauges are located near the pump discharge. Two pressure gauges are located at this point because of a filter system which is also installed near the pump discharge. The need for two pressure gauges will be discussed later. The pressure readings taken by the consulting Irrigation Engineer on both pressure gauges was 30 psi when the irrigation pumping plant was in operation. The drip irrigation system was applying water to 10 acres of Anthuriums at the time.

As indicated above, psi can be converted to feet of lift by multiplying by 2.31. Thus, 30 psi is equal to 69 feet of lift (30 x 2.31 = 69). As indicated, the pump performance curve shows the total lift as 160 feet when the pump is discharging 680 gpm. Again, is indicated above, total lift includes pressure and distance water is lifted out of the well. Thus, the distance the water is being lifted out of the well is 91 feet **(total lift as shown on the pump performance curve of 160 feet minus the pressure of 69 feet = 160 - 69 = 91).** Ms. Vaughan indicated the pump is located about 110 feet down the well and the static water level is 38 feet (water level when pump is not operating). The water level in the well during pumping will be lower than the static level due to drawdown. The total lift of 160 feet is realistic given the above data.

Horsepower required to operate the Blooming Things Farm irrigation pumping plant can be calculated with the following formula:

$$\text{Horsepower (HP)} = \frac{\text{gallons/minute pumped x total lift in feet}}{\text{3960 x pumping plant efficiency}}$$

With the pump delivering 680 gallons/minute with a total lift of 160 feet, it will require 42 horsepower.

$$\mathbf{HP} = \frac{680 \times 160}{3960 \times 0.66}$$

$$= 42$$

The pump performance curve indicates the turbine pump should operate at 75% to 79% efficiency (follow the - -x- -x- on the performance curve) when pumping 680 gpm at 160 feet of total head. Thus, the 42 horsepower shown in the above calculation should be what is being required with a 66% efficient pumping plant **(electric motor at 80% efficiency and pump at 75% efficiency = 0.80 x 0.75 = 0.66, as discussed above).**

Kilowatts used per horsepower equals 0.746. Thus the 42 HP electric motor should be using 31 kilowatts per hour (42 x 0.746 = 31).

The pump is being driven by a 60 horsepower electric motor. The operating characteristics of an electric motor is such that even though the motor size is 60 horsepower, it will only use or draw the amount of kilowatts of the 42 horsepower required which is 31 kilowatts per hour or whatever load is needed at the time the pump is operating.

MEASURING INSTRUMENTS

Two measuring instruments on an irrigation pumping plant which can be valuable water management tools to the irrigator are a pipeline water flow meter and a pressure gauge installed in the discharge pipe of the pump. As daily or periodic readings are made of these two measuring instruments (readings should be recorded for future reference), accurate quantity of irrigation water delivered and available can be determined. Very important also, is the irrigator can note changes that may occur on the measuring instrument readings, especially when such readings begin to decrease. This indicates that problems may be developing in the irrigation pumping plant such as pump wear, a break (water leak) in the pipeline, etc. Inspections can be made of the irrigation system to locate the problem(s) which may not have been visible if the pipeline water flow meter and/or pressure readings had not been available.

BLOOMING THINGS FARM WATER QUALITY

Ms. Vaughan indicated that the well had been redrilled this past January. The pumping capacity of the new irrigation pumping plant was increased over the original. Ms. Vaughan also indicated that the water from the new well has contained a large amount of calcium particles (silts) in the water being pumped, such large quantities of silt that the filtering system was unable to handle it when pumping first began. The irrigators have had to frequently flush the silts from the irrigation pipes and micro-jets. They have experienced an amazingly small amount of problems pumping such a large quantity of silt through the drip irrigation system. Indications are the well is beginning to pump less and less silt. A Hydrologist has indicated that the well will eventually quit pumping the calcium silt, or at least the amount will be reduced significantly.

FILTER SYSTEM

As indicated, the filter system has not functioned properly. When the filter was installed during the April 10 irrigation pumping plant in operation, the pressure loss through the filter was around 40 psi (the pressure reading ahead of the filter read 50 psi and at the discharge end of the filter 10 psi). This is far above the acceptable normal pressure loss of a filter system. Pressure loss through a filter should be no more than 5 to 7 psi. The filter was removed to obtain the above irrigation pumping plant readings.

REFERRING TO THE FILTER INSTALLATION AND OPERATIONS MANUAL, THE MAXIMUM WATER FLOW FOR THE BLOOMING THINGS IRRIGATION PUMPING PLANT FILTER IS 550 GPM. THUS, THE PRESENT FILTER NEEDS TO BE REPLACED WITH A FILTER THAT WILL HANDLE 650 TO 700 GPM.

An adequate filtering system is a must for a drip irrigation system. Knowing the amount of water an irrigation pumping plant is pumping is very important for selecting a filter size. See well drilling discussion below.

SILT AND THE SUBMERSIBLE IRRIGATION PUMPING PLANT

A submersible pump and motor is very susceptible to wear when pumping silt. Since installation, it is likely that a significant amount of wear may have taken place on the pump impellers and electric motor seals and bearings. Even now, as silt is being pumped with the water, though it is much less than at the beginning, pump impeller and motor seals and bearing wear is continuing. If the well continues to produce even a small amount of silt, continual problems can be anticipated in the submersible irrigation pumping plant.

DRILLING AN IRRIGATION WELL

When an irrigation well is drilled, the well driller should be responsible not only to drill the well and install the well screen and casing, but also to develop the well. Developing a well includes pumping the well with the drillers own pumping equipment. The well should be pumped slowly at first while gradually increasing the pumping rate until maximum yield from the well is reached. Surging of the well should also be done to move all the silts out of the aquifer (area from which water flows into the well).

Where silt is anticipated in an aquifer, the well driller should gravel pack the well (pea sized rock placed around the outside of the well screen). The gravel pack holds back the silt from flowing into the well with the water once it has been properly developed as indicated above. A properly constructed irrigation well should produce very little silt, if any at all.

When the irrigation well development process is completed - completed when essentially no silts remains in the water being pumped - the well driller should pump the well at different rates of flow and measure the distance that water has to be lifted out of the well at each flow rate. This information should be provided to the owner of the irrigation well. This information is essential for designing an efficient irrigation pumping plant, selecting a filter system, etc.

IT IS RECOMMENDED BY THE CONSULTING IRRIGATION ENGINEER THAT THE SUBMERSIBLE PUMP AND MOTOR BE TAKEN OUT OF THE WELL AFTER THE PEAK USE TIME (IN THE FALL MONTHS SOMETIME) AND BE INSPECTED FOR WEAR BY A PUMP DEALER AND THE NECESSARY REPAIRS BE MADE. AGAIN, PERIODIC RECORDING OF THE PIPELINE WATER FLOW METER AND PRESSURE GAUGE READINGS SHOULD BE MONITORED VERY CLOSELY FOR SIGNS OF ANY PROBLEMS DEVELOPING IN THE IRRIGATION PUMPING PLANT.

BLOOMING THINGS FARM IRRIGATION SYSTEM

Blooming Things Farm is now irrigating 10 acres of Anthuriums using micro-jet drip irrigation. Plans are to add 6 acres of irrigated Anthuriums using the spinner type drip irrigation and 9 acres of Gingers using overhead sprinklers. The irrigation equipment for both the 6 acres of Anthuriums and 9 acres of Gingers has been purchased by Blooming Things Farm and ready for installation. The Blooming Things farm labor will do the installation.

The Anthuriums (present and future acreage) are grown under shade covers while the Gingers are grown out in the open. During the summer months, a misting system is used to cool the Anthuriums during the hot portions of the day. The irrigation pumping plant used for the micro-jet irrigation system along with booster pumps pump the water for the misting system.

DRIP IRRIGATION SYSTEM WATER APPLICATION RATES ON ANTHURIUMS AREA

One and a half inches of irrigation water can be applied to the Anthuriums area through the micro-jet irrigation system with a pumping rate of 650 gpm. **450 gpm = 1 inch of water in 1 hour on 1 acre or 680 gpm is equal to 1.5 acre-inches of water in one hour (680 / 450 = 1.5).**

When irrigating the 10 Acres of Anthuriums, the following inches of irrigation water is applied in the time periods shown in hours **(gross = 1.5 / 10 = 0.15 x hours, net = 1.5 / 10 = 0.15 x hours x 0.90):**

HOURS	INCHES/ACRE (GROSS)	INCHES/ACRE (NET)
1	0.15	0.14
2	0.30	0.27
3	0.45	0.41
4	0.60	0.54
5	0.75	0.68
6	0.90	0.81
7	1.15	1.04

When irrigating the Future 6 Acres of Anthuriums, the following inches of irrigation water are applied in the time periods shown in hours (**gross = 1.5 / 6 = 0.25 x hours, net = 1.5 / 6 = 0.25 x hours x 0.90**):

HOURS	INCHES/ACRE (GROSS)	INCHES/ACRE (NET)
1	0.25	0.23
2	0.50	0.45
3	0.75	0.68
4	1.00	0.90

Gross irrigation water application is 100% of the irrigation water getting to the crop (Anthuriums) roots. This is difficult to do for various reasons (dripper or emitter spacings, water being applied outside of the beds, etc.) A good rule of thumb for micro-jet and spinner drip irrigation is to use 90% efficiency as the net amount of irrigation water getting to the crop (Anthuriums) roots.

IRRIGATION SCHEDULE FOR ANTHURIUMS

THE ABOVE TABLES SHOW IT REQUIRES ABOUT 7 HOURS OF IRRIGATION TO APPLY 1 INCH OF WATER (NET) ON THE 10 ACRES OF ANTHURIUMS AND 4 HOURS TO APPLY 1 INCH OF WATER (NET) ON THE 6 ACRES OF ANTHURIUMS PUMPING 680 GPM.

If it is desirable to keep the Anthuriums in a humid - tropical environment, it appears 2 to 2.5 hours of irrigation/day during the week is ideal for the 10 acres of Anthuriums applying 0.27 to 0.35 inches of water per acre (net). For the 6 acres, 0.23 to 0.35 inches of water per acre (net) can be applied in 1.0 to 1.5 hours/day irrigation during the week.

Then, additional irrigations on Saturday or Sunday of 7 hours on the 10 acres and 4 hours on the 6 acres will apply 1 inch of water per acre (net).

With the amount of water being pumped of 680 gpm, each Athuriums area (10 acre area and 6 acre area) need to be irrigated separately. There is enough water and pressure to irrigate all sections at one time in the 10 acres and then all sections at one time in the 6 acres.

THE CONSULTING IRRIGATION ENGINEER RECOMMENDS WHEN THE 6 ACRE IRRIGATION SYSTEM IS INSTALLED THAT THE PRESENT 10 ACRE 4 INCH PVC MAINLINE BE EXTENDED TO DELIVER WATER TO THE WEST SECTIONS OF THE 6 ACRES AND THE NEW 4 INCH PVC MAINLINE BE INSTALLED TO SERVE ONLY THE SOUTH SECTIONS OF THE 6 ACRES. THIS WILL GIVE THE FLEXIBILITY TO IRRIGATE PORTIONS OF THE ACREAGE IN BOTH THE 10 ACRES AND 6 ACRES AT THE SAME TIME.

GINGERS SPRINKLER IRRIGATION SYSTEM

The irrigation system designed for the Gingers field includes 96 overhead sprinkler heads with 11/64th inch nozzles. The nozzles should operate at 40 psi. The following single nozzle performance chart indicates at 40 psi, each 11/64th inch nozzle will discharge 5.4 gpm:

PERFORMANCE TABLE FOR SINGLE NOZZLE

Noz Press PSI	#10 noz 5/32" Turquoise		#10½ noz 21/128" Turq & Yel		#11 noz 11/64" Yellow		#11½ noz 23/128" Yel & Red		#12 noz 3/16" Red		#12½ noz 25/128" Red & White	
	GPM	DIA	GPM	DIA	GPM	DIA	GPM	DIA	GPM	DIA	GPM	DIA
25	3.5	79	3.9	81	4.3	83	4.6	84	5.0	85	5.4	86
30	3.8	81	4.2	83	4.6	85	5.0	86	5.5	87	6.0	88
35	4.2	83	4.6	85	5.0	87	5.5	88	6.0	88	6.5	89
40	4.5	85	4.9	87	5.4	88	5.9	89	6.4	90	7.0	92
45	4.7	86	5.2	88	5.7	89	6.2	90	6.8	92	7.4	94
50	5.0	87	5.5	88	6.0	91	6.6	92	7.2	94	7.8	95
55	5.2	88	5.7	89	6.3	92	6.9	94	7.5	95	8.2	97
60	5.4	88	6.0	90	6.6	93	7.2	94	7.8	96	8.5	98
65	5.7	89	6.2	91	6.8	94	7.5	95	8.2	97	8.8	99
70	5.9	90	6.5	92	7.1	94	7.8	96	8.5	98	9.1	99

With 96 sprinkler heads and nozzles, the total water discharge will be 518 gpm (96 x 5.4 = 518). Referring once again to the pump performance curve, the pump will discharge 518 gpm with a total head of 190 feet. The 40 psi equals 92 feet of head (40 x 2.31 = 92) and the remaining head will be the distance water is lifted out of the well of 98 feet (190 - 92 = 98). According to the pump performance curve, the pump will discharge less gpm at the 40 psi for the Gingers field than at the 30 psi for the Anthuriums fields.

The irrigator needs to have available a special nozzle pressure gauge to read pressures at the nozzles. If the pressures are below the 40 psi as required, the discharge of the nozzles will be less then the 5.4 gpm. Visa versa is also true - more pressure, more gpm's.

WATER APPLICATION RATES FOR THE GINGERS AREA

The 518 gpm is equal to 1.15 acre-inches of water per hour (518 / 450 = 1.15). The following amounts of irrigation water can be applied on each acre of the 9 acres of Gingers for the designated hours: **(gross: 1.15 / 9 = 0.13 x hours, net: 1.15 / 9 = 0.13 x 0.80 x hours):**

HOURS	INCHES/ACRE (GROSS)	INCHES/ACRE (NET)
1	0.13	0.10
2	0.26	0.21
3	0.39	0.31
4	0.52	0.42
5	0.65	0.52
6	0.78	0.62
7	0.91	0.73
8	1.04	0.83
9	1.17	0.93
10	1.30	1.04

Efficiency for an overhead sprinkler is approximately 80% as used in the above table as net irrigation amounts. Efficiencies for overhead sprinklers is lower then drip irrigation because of wind drift, evaporation, uniformity of application, etc. Again, the above application rates are based on 500 gpm.

SOME IRRIGATION PRINCIPLES

No matter which irrigation methods and practices are used, it is necessary for the irrigator to understand some basic principles about soils and plants in order to obtain maximum efficiency of the resources and, therefore, optimum production.

Soils

In irrigation, the soil's most important function is to store water and nutrients for the plants. A soil's texture is the major factor affecting how much water it can hold for the plants. "Available water" refers to the amount of water that a soil can store and is accessible for plant use. Not all the water stored in the soil is available for the plant to use. Available water is the difference between field capacity (the most water the soil can hold in the plant root area) and permanent wilting point (soil water condition reached after the plant is unable to take any more water from the soil - the soil is not completely dry, but the plant is unable to take any more water from the soil).

The following table shows the "available water" for the different soil textures:

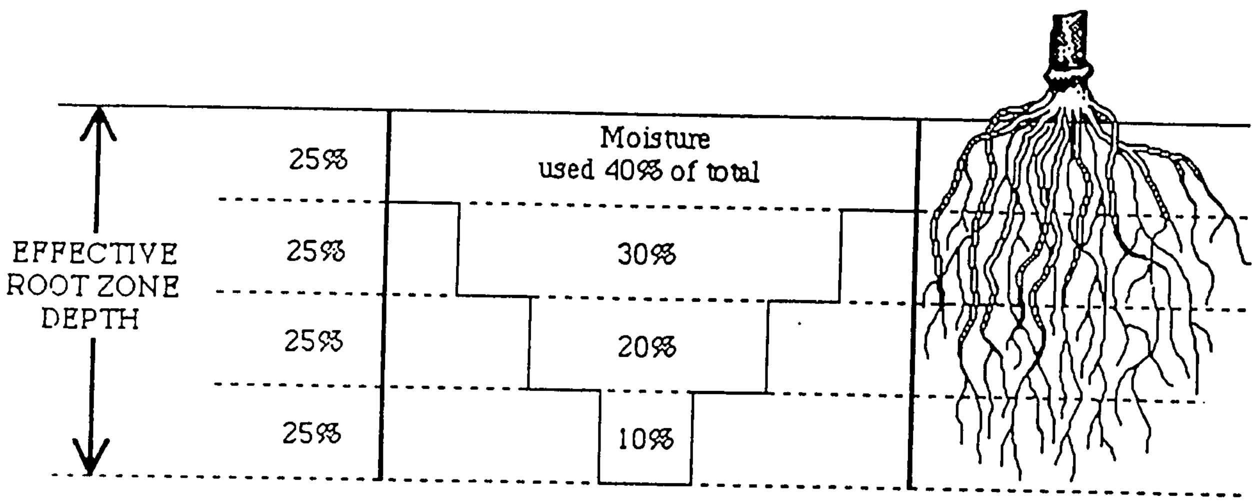
SOIL TEXTURE	AVAILABLE WATER (INCHES/FOOT)
SANDY	0.5
SANDY LOAM	1.0
LOAM	1.6
CLAY LOAM	2.0
CLAY	1.8

On the Blooming Things farm, the soils are a clay loam soil in texture, thus hold 2.0 inches of available water per foot of soil for plant use when at field capacity (filled with water).

PLANTS

The roots of the plants are in contact with the soil and feed the plants with water and nutrients as available in the soil.

Root depths vary by crops. Root depths for flowers such as Anthuriums and Gingers are found mostly in the top foot of the soil area - a small amount of the roots may find their way to a bit deeper depth. About 70% of all the plant roots are located in the top half of the root zone. **Thus, the Gingers will take their water supply and nutrient needs from about the top 9 or so inches of soil.** The distribution of the plant roots as found in the soil is approximately as shown in the following figure:



PLANT ROOT DISTRIBUTION IN THE SOIL

DEPTH OF IRRIGATION

In applying irrigation water, the goal is to fill the soil with water in the entire root area and no more. Even though 70% of the water is taken by the plant from the top half of the effective root area, irrigation water should still be applied throughout the entire plant root depth. **APPLY IRRIGATION WATER TO A DEPTH OF 12 INCHES FOR THE GINGERS.** As water is applied to the soil, the soil surface area takes the water first and then the water moves down deeper into the soil. The more irrigation water that is applied, the deeper the soil is wetted. The goal is to apply just enough irrigation water to fill the soil to the depth of the plant roots. Wetting the soil below the plant root area is not beneficial unless it is necessary at times to move salts out of the root zone area. The downward movement of water below the plant roots has several disadvantages such as carrying plant nutrients beyond where the plants can use them, water logging the soil, etc.

IRRIGATION SHOULD BEGIN WHEN 50% OF THE AVAILABLE WATER HAS BEEN DEPLETED FROM THE SOIL IN THE PLANT ROOT ZONE AREA. As indicated above, the soils on the Blooming Things farm are a clay loam holding 2.0 inches of available water per foot of soil. Thus, irrigation should begin after 1.0 inch of water has been depleted from the root zone area (2.0 x 0.50 = 1.0).

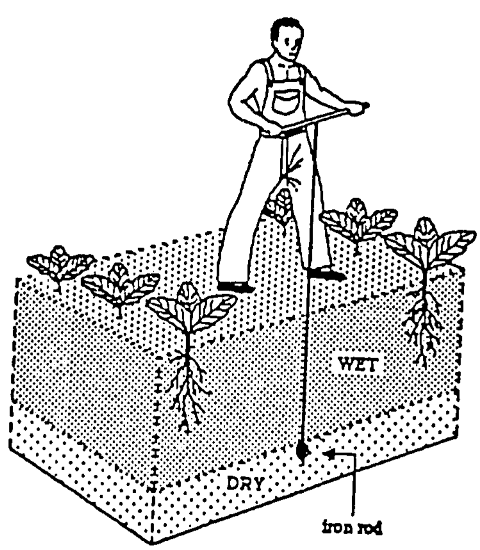
Available water remaining in the soil for plant use can be approximated by feeling and by the appearance of the soil. The irrigator needs to have a soil auger available to "pull" soil samples from different depths in the soil to feel it and determine available water remaining for plant use. Using the feel and appearance method to estimate the available water for a clay loam soil is illustrated in the following page. Also, a more detailed chart for using the feel and appearance method for estimating the available water is attached following the illustration page.

Take soil samples to a depth of 9 inches throughout the Gingers area. For a clay loam soil, when squeezing and feeling the soil samples and the soil begins to be crumbly, yet forms a ball when applying pressure when squeezing the soil in the palm of the hand, about 50% of the available water has been depleted from the Gingers root area. Then irrigation should begin. This is illustrated on the following pages.

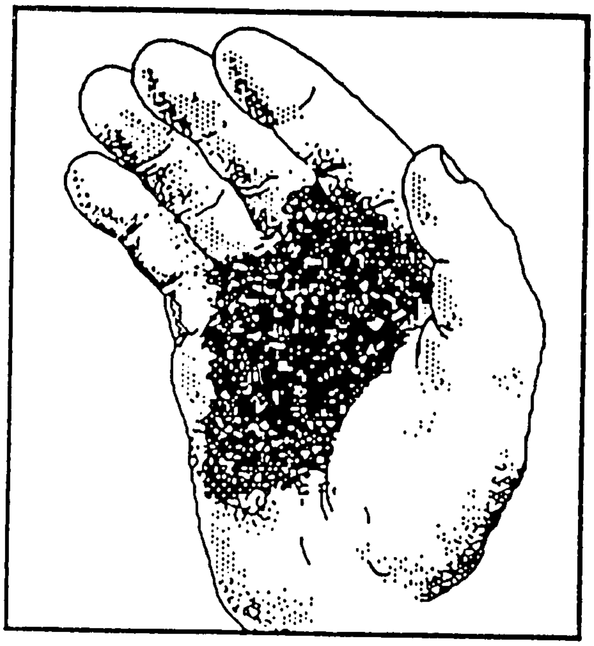
IRRIGATION SHOULD BE STOPPED WHEN IRRIGATION WATER HAS REACHED A DEPTH OF 12 INCHES OR SO IN THE SOIL WHEN IRRIGATING THE GINGERS (DEPTH OF THE ROOTS AS DISCUSSED ABOVE).

A way to determine how deep the irrigation water has gone in the soil, an irrigator can use an iron rod. The iron rod is 3/8 inch in diameter and 3 feet in length with an enlarged tip or end. In wet soil, the rod will push into the soil very easily. When the tip or end of the rod reaches dry soil, it will push harder. The point at which the rod begins to push harder is the line between the wet soil and dry soil.

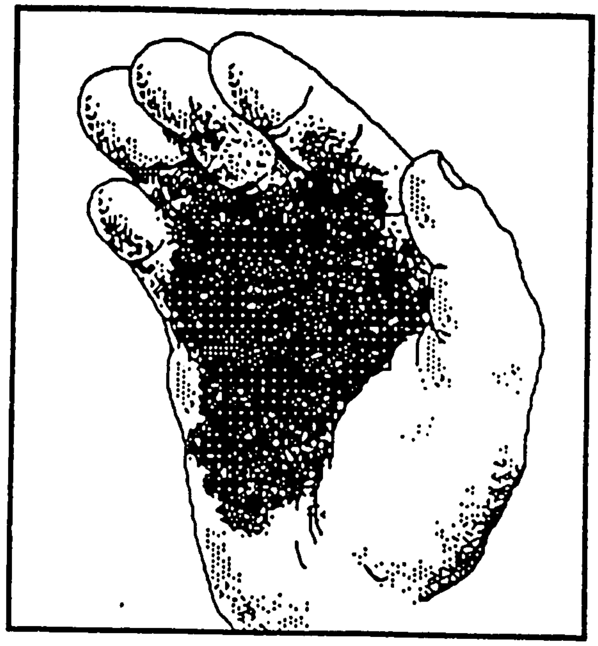
Using the iron rod is shown in the following figure:



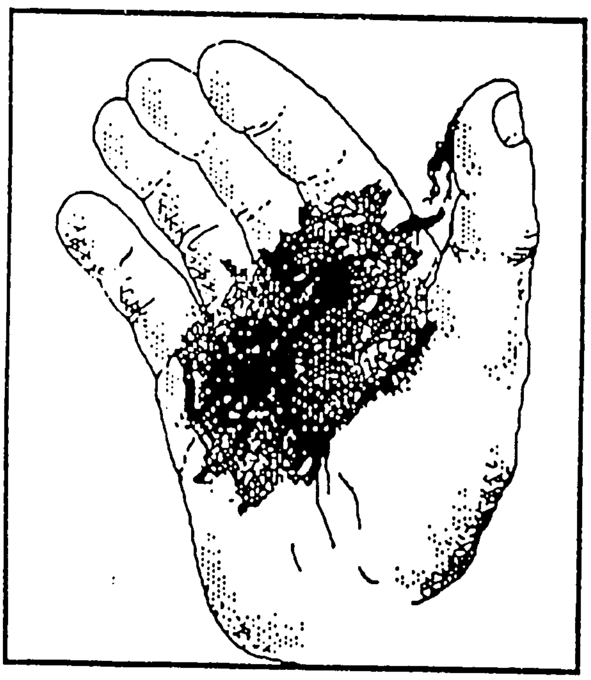
USING THE IRON ROD



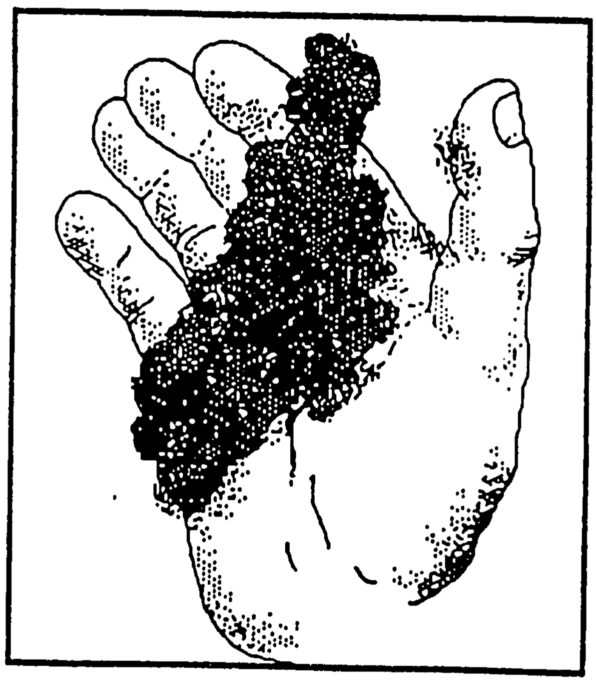
* 0 to 25% Available Moisture - Crumbles readily, "balls" with difficulty and breaks easily.



* 25 to 50% Available Moisture - Does not crumble, easily, forms readily, will "ball" with pressure.



* 50 to 75% Available Moisture - Forms "ball" readily, will "ribbon" out between thumb and forefinger. Somewhat slick feeling.



* 75 to 100% Available Moisture - Easily "ribbons" out. Has slick feeling.

USING THE FEEL AND APPEARANCE METHOD FOR FINE TEXTURED SOILS
CLAY LOAMS AND SILTY CLAY LOAMS
TO ESTIMATE AVAILABLE WATER

FEEL AND APPEARANCE CHART FOR AVAILABLE MOISTURE IN THE ROOT ZONE

	Soil Texture			
Percentage of Soil Moisture Remaining	[Sands] (Loamy Sandy)	[Sandy Loams] (Fine Sandy Loams)	[Loams and Silt Loams] (Clay Loams)	[Silty Clays] (Clays)
0 to 25%	Dry, loose soil flows through fingers [0 to 0.20] (0 to 0.25)	Dry, loose soil flows through fingers [0 to 0.40] (0 to 0.50)	Powdery, dry, crusty [0 to 0.55] (0 to 0.55)	Hard, cracked [0 to 0.50] (0 to 0.50)
25 to 50%	Appears dry, will not form a ball with pressure. [0.20 to 0.40] (0.25 to 0.50)	Appears dry, forms very weak ball under pressure [0.40 to 0.75] (0.50 to 1.00)	Partly crumbly, forms ball under pressure [0.55 to 1.10] (0.55 to 1.10)	Partly pliable, forms good ball under pressure [0.50 to 0.95] (0.50 to 0.95)
50 to 75%	Appears dry, forms very weak ball under pressure [0.40 to 0.60] (0.50 to 0.75)	Almost dry, tends to form a crumbly ball under pressure [0.75 to 1.10] (1.00 to 1.50)	Forms partly plastic ball, may slick with pressure [1.10 to 1.65] (1.10 to 1.65)	Forms ball and will ribbon [0.95 to 1.45] (0.95 to 1.45)
75 to 100%	Tends to stick, forms weak crumbly ball [0.60 to 0.80] (0.75 to 1.00)	Forms weak ball, will not stick [1.10 to 1.50] (1.50 to 2.00)	Forms very pliable ball and may stick [1.65 to 2.20] (1.65 to 2.20)	Easily ribbons and has slick feeling [1.45 to 1.90] (1.45 to 1.90)
100%	The soil is at field capacity. Upon squeezing, no free water appears on the soil, but a wet outline of the ball is left in the hand.			

NOTE: Figures in each parentheses show inches of water available moisture remaining per foot of depth.

The iron rod is not commercially available. It can be easily made in a welding shop using 3/8 inch rod welding a "T" on one end for a handle and a 1/2 inch ball bearing on the other end as the enlarged tip or end.

There are limitations where the iron rod can be used. In gravelly or very course soils, where there are rocks present in the soil profile, it may not be possible to push the iron rod into the soil. The soil auger, used for taking soil samples as discussed above, may need to be used in such kinds of soils. Even the soil auger may be difficult to use in gravelly, coarse soils. But it doesn't appear the soils on the Blooming Things farm will be any problem for using the iron rod.

SOIL MOISTURE INSTRUMENTS

Technology is available today where instruments such as tensiometers and gypsum blocks can be installed in the soil which indicate when irrigations should begin. **HOWEVER, THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THE FEEL AND APPEARANCE METHOD ALWAYS BE USED TO ESTIMATE AVAILABLE WATER EVEN WHERE SOIL MOISTURE INSTRUMENTS ARE USED. USING THE FEEL AND APPEARANCE METHOD, THE IRRIGATOR WILL BE REQUIRED TO WALK THE FIELDS RESULTING IN BECOMING VISUALLY BETTER ACQUAINTED WITH THE CROP AND SOIL CONDITIONS. THIS IS MOST IMPORTANT IN IRRIGATION MANAGEMENT ON A FARM.**

CROP CONSUMPTIVE WATER USE REQUIREMENTS

The crop consumptive water use requirement is the water use of any specified well-watered crop under optimum growing conditions. Crop consumptive use is usually considered the maximum water use of a crop for the given conditions. As a guide, it is estimated that Gingers will use between 0.15 inches or water/day in the cooler months of the year to 0.25 inches of water/day in the hotter months. An irrigator can anticipate having to irrigate the Gingers about every 12 or 13 days in the cooler months (2.0 / 0.15 = 13) or every 8 days in the hotter months (2.0 / 0.25 = 8).

RAINFALL

Mean rainfall in Jamaica including at Blooming Things farm will exceed the water consumptive of the plants on the farm. However, not all the rainfall is effective or not all enters the soil. Rainfall intensities at times are such that the soils are unable to absorb all the rainfall, causing runoff. Therefore, it is important to have rain gauges located throughout the farm, even in the shade houses, to provide rainfall information as part of the irrigation management program. The rain gauges will not measure the effective rainfall, but will provide valuable information relating to rainfall amounts and times for the farm. It is important to sample the soil periodically to feel it and observe its appearance to determine available water as the guide for determining when irrigations should be scheduled. Use the iron rod after rains to determine how deep the rain waters have penetrated the soil.

IRRIGATION SCHEDULE FOR GINGERS

As indicated earlier, when 50% of the available water has been depleted by the Gingers plants from soil in the root zone area (**DETERMINED BY THE IRRIGATOR "PULLING" SOIL SAMPLES**), it is time to irrigate.

The same irrigation pumping plant used to irrigate Gingers is also used by the farm to irrigate and mist the Anthuriums. Thus, an irrigation schedule for the Gingers will need
to be worked in with the Anthuriums irrigation and misting schedule. The Gingers irrigation schedule will need to be during the weekdays because Anthuriums are irrigated a length during the weekend days of Saturday and Sunday.

During the cooler months when the misting (cooling) system is not in use, water is needed to irrigate the Anthuriums for a about a total of 4 hours each weekday (10 acre area for 2.5 hours and the 6 acre area for 1.5 hours). In a 12 hour day, this leaves 8 hours/day for operating the Gingers field irrigation system **(the entire 9 acres of Gingers can be irrigated at the same time)**. To replace 1.0 inch of water per acre on the Gingers field (depleted water), it will require 10 hours to replace the 1.0 inch **(above table - 10 hours to apply 1.04 inches of water, net)**. This can be done by irrigating 5 hours for 2 days giving a total of 10 hours of irrigation required. Or, any other combination of 10 hours of irrigation such as operating into the night, irrigating 10 hours in one day. Or, irrigating for 4 hours in two days and 2 hours for one day.

Here is where the iron rod can be used to make sure the irrigation water reaches the 1 foot depth after 10 hours of irrigation. Then after about 2 or 3 days when the irrigation has been completed, the irrigator than begins to "pull" daily soil samples to feel and observe the soil. Once the soil samples indicate that 50% of the available water has been depleted again, the next irrigation should begin.

Things get a bit more difficult when the misting (cooling) system is used during the hotter days. If the misting system is used for 5 hours in addition to the 4 hours irrigation time for the Anthuriums, This leaves only evening and night time hours for irrigating the Gingers. Again, 10 hours of irrigation will be required to replace the 1.0 inch of depleted water. one night time irrigation of 10 hours in length, may be an irrigation schedule that can be used. Or, whatever best fits the farm management such as 5 hours for 2 nights, etc.

ADDITIONAL WATER EQUIVALENTS

ONE CUBIC FOOT OF WATER = 7.5 GALLONS
ONE CUBIC FOOT OF WATER = 62.4 POUNDS
ONE CUBIC FOOT PER SECOND (CFS) = 450 GALLONS/MINUTE
326,000 GALLONS = 1 ACRE-FOOT OR 12 ACRE-INCHES OF WATER

OPERATING AND MAINTAINING THE BLOOMING THINGS IRRIGATION SYSTEM

Diesel Engine and Generator Unit

Operator must know the operator's manual well.

Post the daily and weekly maintenance and inspection schedule check lists for the diesel engine/generator unit in the pump house for easy access. Reference should be made to the check lists by the operator every time the daily and weekly observations are made. Even the best of airline pilots refer to the check list in their handbook, every time, before takeoff even though they know the check list frontward and backward. Daily and weekly maintenance and inspection check lists are available in the diesel engine/generator operator's manual. Make a copy of such and post in the pump house.

Monthly, 250 hours of operation and annual maintenance and inspection schedule check lists are also available in the operator's manual. Keep the operator's manual handy for easy access to these maintenance and inspection schedule check lists.

Follow such maintenance and inspection schedules faithfully will result in the least expensive life time operation of the unit.

Periodically record all gauge readings on the generator and diesel engine panel - again, posted in the pump house. Subtle changes often go undetected unless gauge readings are recorded and reference made to the recordings.

Irrigation Pumping Plant

Generally, no special maintenance is required of a submersible irrigation pumping plant. However, where silt is in the water and is pumped, the submersible irrigation pumping plant is very susceptible to wear in situations as such. Pressure gauge and a pipeline water flow meter readings should be recorded periodically and posted in the pump house. Any changes in the readings are excellent indicators of problems that may be developing in the irrigation pumping plant such as pump wear and/or problems throughout the irrigation system such as water leaks in the pipeline, etc. Replace the pressure gauge(s) about every 5 years. The pipeline water meter should be checked by a dealer every 5 years.

Filtering System

The heart of the drip irrigation system, in addition to the drippers, is the filtering system. It is important to keep the irrigation water silts out of the drip system to eliminate micro-jet and spinner plugging. Maintenance of the filter system is to keep it properly flushed to keep the pressure and water flow adequate throughout the operation of the irrigation system. A clogged filter will decrease the irrigation system's pressure and flow. Two pressure gauges are located on the filter, one on the upstream side of the filter and one at the downstream side. The normal pressure difference between the upstream and downstream gauges should be 5 to 7 psi. Any pressure difference significantly greater is due to silt lodged in the filter to the level it needs to be flushed or drained. In periodic flushing or draining, one can anticipate the time before the next flushing or draining needs to be made. If the flushing or draining time is very short, the drain value can be left open so a few gallons flow (very low flow) from the valve keeping the silt basin on the filter emptied.

Inspect the filter annually to determine if there is any wear or breakage that would require replacement of the filter itself.

Ms. Vaughan, General Farm Manager, indicated that the filter screen has clogging very rapidly. As indicated earlier, the flow rating of the present filter is 550 gpm. The flow is 680 gpm. Thus, the present filter must be replaced with one that can operate properly for the flow rate of the irrigation pumping plant.

Chemical Injector

Reference needs to be made to the chemical injector operation and maintenance manual. Each injection system has its own maintenance requirements that need to be followed.

Micro-jet, Spinner and Overhead Sprinkler Systems

Replace broken micro-jet, spinner or sprinkler heads immediately and as needed for uniform, even water distribution.

IRRIGATION SYSTEM OPERATION

One person should be designate with the responsibility to continuously walk the area being irrigated to note problems and correct such as:

* Micro-jets, spinners or sprinkler heads not operating properly - clean, unplug, or correct the problem that causes heads to not rotate properly - very important that heads operate properly for uniform water application.

* Replace heads with the same heads that in use such as micro-jets with micro-jets, spinners with spinners, nozzles sizes with the same nozzle size, etc. Do not intermix drip heads or sprinkler heads to keep uniform water application.

* Leaning micro-jets, spinners or sprinklers - heads should be vertical, not leaning, for uniform water application. (consulting Irrigation Engineer noted numerous micro-jets fallen down - just laying in the beds, not setting up at all).

* Space the micro-jets or spinners equal distance and in the center of the bed. Again, this is necessary for uniform water distribution.

* Flush drip irrigation pipelines periodically.

* Water leaks or chinks in the pipeline(s) which reduces flow to the micro-jets or spinners in that area. Replace broken or chinked pipes. Pipe splicing replacement parts are available.

* Spaghetti lines - small water lines connecting the micro-jets to the lateral line should all be of uniform length. The spaghetti line length controls the amount of water that flows to the micro-jets or spinners.

ADDITIONAL RECOMMENDATIONS

* The individual designated above to walk the area during irrigations, also, be designated to take and record soil samples readings, depth of irrigations by using the iron rod, read and record pressure readings and read and record pipeline water flow meter readings. To do this the following equipment must be made available to the irrigator worker:

    * a soil auger.

    * an iron rod.

    * a nozzle pressure gauge.

* Place a rain gauge on the farm somewhere around the home area.

* Have on hand extra micro-jet heads, spinners and overhead sprinkler heads for immediate replacement of damaged heads.

* A number of the plastic valves on the existing micro-jet irrigation system have broken parts and do not operate properly. The consulting Irrigation Engineer recommends the plastic valves be replaced with brass globe valves. The irrigation system is operating at pressures to high for plastic valves, thus replacing them with brass valves will eliminate the problem.

* Replace present filter with a larger filter to handle the 650 to 700 gpm pump discharge flows.

AVAILABLE REPLACEMENT IRRIGATION EQUIPMENT IN THE COUNTRY

The Consulting Irrigation Engineer visited with the following Jamaican irrigation equipment dealers and suppliers:

* Caribbean Industrial Equipment - Kingston

* Ladimar Irrigation - Kingston

* Pumps and Irrigation - Kingston

* Jamaica Drip Irrigation - Mandeville

All the above dealers and suppliers indicated that they carry a large inventory of irrigation replacement supplies for both drip and sprinkler irrigation systems and for irrigation pumping plants. If one dealer or supplier does not have the replacement parts required for the irrigation system in use by an irrigator, one of the others may have it available.

INSTALLATION OF THE FUTURE IRRIGATION SYSTEMS

* All irrigation equipment and supplies are available for installation on the 6 acres of Anthuriums and the 9 acres of Gingers to be added. The Anthuriums are to be irrigated using spinner drip irrigation and the Gingers using overhead sprinklers.

* The consulting Irrigation Engineer reviewed the designs and equipment inventory. The Blooming Things farm labor will be doing the installation of the irrigation systems. All the irrigation equipment and supplies appear to be appropriate. However, the consulting Irrigation Engineer

recommends two changes in the 6 acre spinner drip irrigation system. One - replace the plastic valves with brass globe valves before even installing the plastic valves. Such brass valves are available at the Jamaican irrigation equipment dealers and suppliers as indicated above. Two - suggest not to install the valve controller.

Interconnecting the 10 acre system and 6 acre system as indicated above, manual brass globe valves provides an easier alternative for operating a number of sections in the 10 acre and 6 acre areas simultaneously.

Ms. Vaughan expressed concern about leaving the sprinklers in the field during the night once installed in the Gingers area. Consideration may want to be given to paying an incentive to an irrigation worker to guard the sprinkler field during the times the sprinklers are in use during the night time and/or holiday hours. A tremendous amount of labor will be required to remove the sprinklers and put them back during irrigations.

IRRIGATION TRAINING

The consulting Irrigation Engineer worked with and provided training for Blooming Things farm irrigation workers throughout the time of visit on the farm. The workers included Mr.Richardo Whyte, irrigation supervisor, Mr. Morris West, irrigation worker, Mr. Lester Jones, irrigation worker, Mr. Castley Smith, irrigation worker and Ms. Hilda Vaughan, General Farm Worker. Rechardo Whyte and Lester Jones were hired during the time the consulting Irrigation Engineer was working on the farm. The consulting Irrigation Engineer would rate the irrigation workers as very knowledgeable and capable for operating and managing the Blooming Things irrigation system and irrigation pumping plant.

The University of West Indies will be conducting an irrigation short course on May 29 to June 9, 1995. The short course is entitled "Irrigation: Principles and Practices for Caribbean Agriculture". The consulting Irrigation Engineer visited with coordinators of the irrigation short course. It was indicated that the short course will be geared for students with a High School Diploma or above. The consulting Irrigation Engineer recommends Blooming Things farm consider sending one of their irrigation workers to attend the irrigation short course.

JAMAICAN FLORAL EXPORTS (1993) LIMITED

ST. MARY

OCHO RIOS, JAMAICA

IRRIGATION REPORT

MARCH 29 - 31 AND APRIL 1, 1995

DONALD J. BROSZ
CONSULTING IRRIGATION ENGINEER

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT

CHEMONICS INTERNATIONAL CONSULTING DIVISION
WASHINGTON, D.C.

JAMAICAN FLORAL EXPORTS (1993)

ST. MARY

OCHO RIOS, JAMAICA

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT SCOPE OF WORK

The consulting Irrigation Engineer will spend the necessary time on the farm to do the following:

* to field inspect the irrigation system and irrigation operations.
* to review current irrigation system maintenance plan.
* to provide training to augment the skills of the Jamaican Floral Exports personnel responsible for irrigation.
* Consulting Irrigation Engineer to provide the Client with a report outlining the results of the work and make recommendations with respect to irrigation.

JAMAICAN FLORAL EXPORTS FARM IRRIGATION RECOMMENDATIONS

FARM IRRIGATION SYSTEM OPERATION, MANAGEMENT AND MAINTENANCE

* Concur with Robert Facey's idea of installing a centrifugal irrigation pumping system.

* Concur that the Grundfos centrifugal pump plant, according to the pump performance curve, will serve the needs of the Jamaican Floral Exports Farm irrigation requirements.

* Concur that a portion of the present 4 inch pvc delivery mainline pipe be replaced with 6 inch pvc.

* Concur that a one foot stand pipe be installed on the two intake mainline pipe in the holding pond.

* Install a pipeline water flow meter in the delivery mainline pipe which discharges water into the holding pond.

* Install 11/64th inch by 1/8th inch nozzles in those sprinkler heads that now have different sized nozzles or no nozzles to provide uniform irrigation water application on all sprinkler irrigated areas.

* Pressure regulators or a pressure gauge and a small brass globe valve be installed at all drip irrigation turn on - turn off points to provide the recommended pressure for the drip emitters.

* Provide Farm Irrigation Supervisor with a soil auger and an iron rod to aid the Supervisor in carrying out his irrigation duties more effectively and efficiently.

IRRIGATION MANAGEMENT REPORT

JAMAICAN FLORAL EXPORTS (1993) LIMITED

OCHO RIOS, JAMAICA

MARCH 29 - 31 AND APRIL 1, 1995

IRRIGATION PUMPING PLANTS

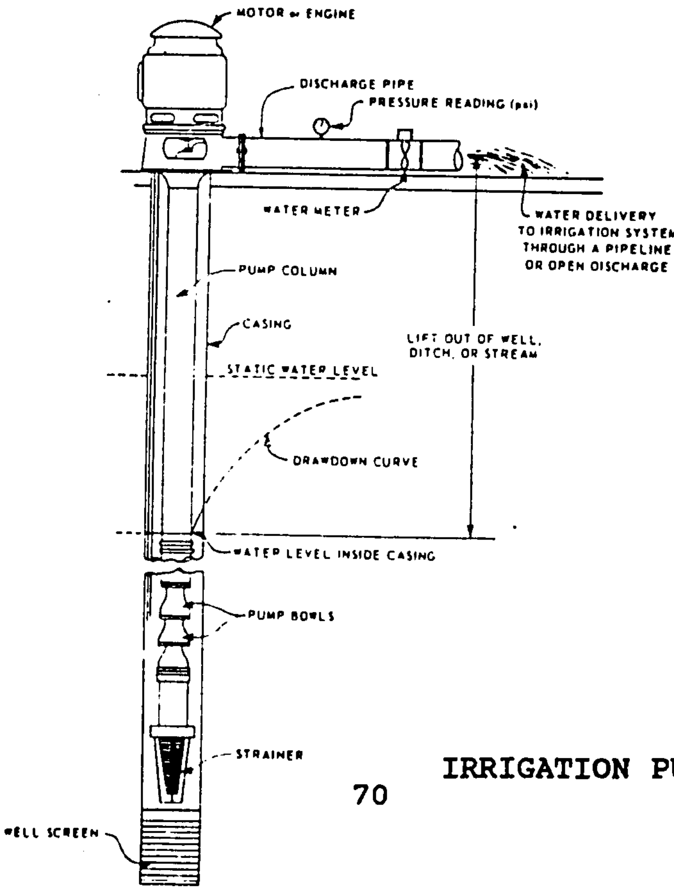
The energy costs for operating an irrigation pumping plant are a major cost to an irrigator. There are four factors that determine the power and energy requirements of an irrigation pumping plant. They are:

1. The quantity of water being pumped generally expressed as gallons per minute (gpm) when a pumping plant is in operation.

2. The depth from which water is lifted in the well to the discharge side of the pump (distance between the water surface in the well while the pump is operating and discharge point at the pump).

3. The pressure at the discharge point of the pump when it is operating, expressed in pounds per square inch (psi).

4. The efficiency of the irrigation pumping plant, expressed in percent.



IRRIGATION PUMPING PLANT

The above figure shows a typical irrigation pumping plant in operation. This shows the power unit located at the surface (electric motor in this case). There are irrigation pumping plants where the electric motor is located in the well with the pump. This type of irrigation pumping plant is known as a submersible motor and pump. It operates exactly the same as the irrigation pumping plant shown in the above figure.

The distance water is lifted out of the well plus the pressure at the pump discharge (2 and 3 above) is expressed as total lift in feet (often referred to as total dynamic head - in this report it will be referred to as total lift). This lift is shown in the above irrigation pumping plant figure - the distance water is lifted to the pump discharge, measured in feet - the pressure reading, measured in pounds per square inches (psi). Everything needs to be in feet. **To convert psi to feet, multiply the psi reading by** 2.31. For example, a pressure reading of 70 psi is equal to 162 feet (70 x 2.31 = 162). Adding the two, distance water lifted out of the well in feet (this distance should be measured by the well driller upon completion of the well) plus the discharge pressure in feet, equals total lift in feet. There is a small additional loss in the pump column or suction side of the pump that should be added to the total lift. However, this generally is a relatively small amount and can be disregarded.

Efficiency of an irrigation pumping plant is an indicator as to the ability of the total irrigation pumping plant to deliver a quantity of water at a required total lift using the least amount of energy. No irrigation pumping plant is 100% efficient, not even a perfectly designed new irrigation pumping plant. Energy is lost within the electric motor or internal combustion engine because of its operating characteristics (slippage, bearing friction, etc.). Power is also lost between the drive shaft and the pump. Energy is also lost in the pump because of its operating characteristics, friction in the well screen, etc. **A typical irrigation pumping plant, properly designed, will operate at approximately 66% efficiency (electric motor 88% and pump 75%** = 0.88 x 0.75 = 0.66). A more accurate irrigation pumping plant efficiency can be determined from a pump performance curve available for every pump. An irrigator should request a copy of the pump performance curve from the dealer at the time the pump is purchased and keep it in the irrigation system file for future reference.

JAMAICAN FLORAL EXPORTS IRRIGATION PUMPING PLANT

Jamaican Floral Exports is pumping water from a stream surface water supply, lifting the water up a hill some 400 feet in elevation through a 4000 foot 3 inch galvanized pipeline and discharging the water into a holding pond. The pond is lined with a Water Saver butyl liner. The capacity of the holding pond is approximately 350,000 gallons or about one acre-foot of water **(326,000 gallons of water is equal to one acre-foot of water).**

The Jamaican Floral Exports irrigation pumping plant is a unique system. The submersible pumping plant is placed horizontally into the stream. Normally, a submersible pump and motor is placed vertically, such as in a well. In order to keep the pump and motor submerged under water in the stream, in this case, it needed to be installed in a horizontal position. This is a good way to install a submersible irrigation pumping plant in a stream. The operation of the submersible irrigation pumping plant in the stream is much like what was discussed above. The total lift for the Jamaican Floral Exports submersible irrigation pumping plant includes the distance water is lifted out of the stream to the pressure gauge in feet, plus the pressure gauge reading in feet. The distance from the stream water surface to the pressure gauge is about 3 feet. The pressure gauge reading while the irrigation pumping plant is in operation reads 230 psi which is equal to 531 feet (**230 x** 2.31 = **531**), or a total lift of 534 feet (531 + 3 = 534). As indicated above, the elevation lift is about 400 feet and yet the pressure gauge reads 230 psi or 531 feet. The quantity of water being pumped is 100 gpm. The friction in a 4000 foot 3 inch galvanized pipe is about 115 feet (taken from pipe friction tables). Thus, 115 feet of the 531 feet of lift is friction loss in the galvanized pipeline and the remaining 416 feet (531 - **115** = **416**) is the elevation difference from the pressure gauge to the discharge at the holding pond.

The submersible pump and motor is a 6 inch Goulds Model. No pump performance curve was available in the Jamaican Floral Exports file. Assumption is made that the irrigation pumping plant is operating at a 66% efficiency. Horsepower required to pump 100 gpm with a 534 foot total lift and a 66% efficient irrigation pumping plant can be calculated by the following formula:

$$\text{Horsepower} = \frac{\text{gallons/minute pumped x total lift in feet}}{\text{3960 x pumping plant efficiency}}$$

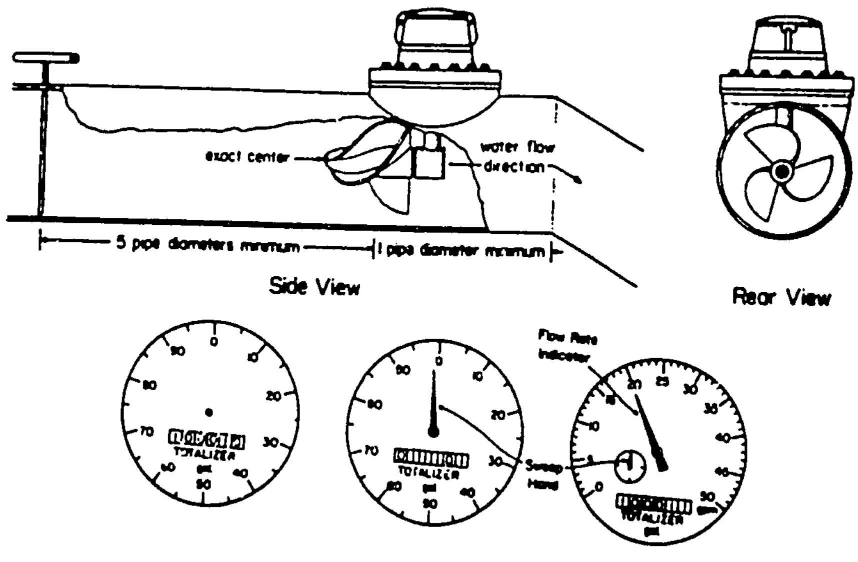
$$\textbf{Horsepower (Jamaican Floral)} = \frac{\mathbf{100 \times 534}}{\mathbf{3960 \times 0.66}}$$

$$= \mathbf{20}$$

The submersible irrigation pumping plant is powered by a 30 horsepower electric motor. When starting up the irrigation pumping plant, more then the 20 horsepower is required. However, once water reaches the holding pond, it requires only 20 horsepower to operate the irrigation pumping plant. The characteristics of an electric motor is such that it will draw only the amount of electricity (kilowatts) necessary to meet the load. For the Jamaican Floral Farms irrigation pumping plant, the electric motor will draw only the amount of electricity required for the 20 horsepower load once water reaches the holding pond, not electricity required for the 30 horsepower. Kilowatt-hours of electricity to operate the 20 horsepower load is 15 (1 **horsepower = 0.746 kilowatts/hour --- 20 x 0.746 = 15).**

QUANTITY OF IRRIGATION WATER BEING PUMPED

To calculate the horsepower required above, 100 gpm was used as the quantity of water being pumped by the irrigation pumping plant. Robert Facey, Jamaican Floral Exports Managing Director, indicated the irrigation pumping plant had been designed to pump 100 gpm. To be sure of the quantity of water an irrigation pumping plant is delivering, a pipeline water flow meter should be installed near or somewhere in the pipeline on the discharge side of the pump. Instantaneous reading of gpm and total quantity of water pumped can be made with a pipeline water flow meter. A typical pipeline water flow meter is shown as follows:



PIPELINE WATER FLOW METER

Two measuring instruments on an irrigation pumping plant which can be valuable water management tools to the irrigator are a pressure gauge and pipeline water flow meter installed in the discharge pipe of the pump. As daily or periodic readings are made of these two measuring instruments, accurate quantity of irrigation water delivered and available can be determined. Very important also is the irrigator can note changes that may occur in the measuring instrument readings, especially when such readings begin to decrease. This indicates that problems may be developing in the irrigation pumping plant such as pump wear, a break (water leak) in the pipeline, etc.

THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THAT A PRESSURE GAUGE (AS NOW INSTALLED AT THE PUMP DISCHARGE) AND A PIPELINE WATER FLOW METER BE INSTALLED ON THE IRRIGATION PUMPING PLANT AND BE PROPERLY MAINTAINED. THE PRESSURE GAUGE SHOULD BE REPLACED ABOUT EVERY 5 YEARS BECAUSE OF WEAR. WHERE SILT IS BEING PUMPED AS IN THE JAMAICAN FLORAL EXPORTS SITUATION, THE PIPELINE WATER FLOW METER SHOULD BE INSPECTED ONCE A YEAR BY AN EXPERIENCED IRRIGATION MAINTENANCE PERSON.

AVAILABLE IRRIGATION WATER

As indicated, the irrigation pumping plant is delivering 100 gpm. This quantity of water is equal to 0.22 acre-inches of water per hour or 5.3 acre-inches in 24 hours of pumping. **450 GALLONS/ MINUTE EQUALS 1 INCH OF WATER ON 1 ACRE IN 1 HOUR OR ONE ACRE-INCH/HOUR.**

As Jamaican Floral Exports completes its construction and planting plans, approximately 25 acres of flowers will be grown - Orchids, Anthuriums, Birds of Paradise, Ruscus (foliage for floral arrangements), Gingers, etc. Just as an example, if the irrigation pumping plant is operated at an average of 12 hours per day, 2.6 acre-inches of water will be available each day for irrigation purposes (0.22 x 12 = 2.6). It will take 10 days to apply 1 inch of water on the total 25 acres when applying all of the water pumped each day (25 / 2.6 = 10).

SPRINKLER IRRIGATION

At present a small sprinkler irrigation system is being used to irrigate some of the Bird of Paradise plants. There are 12 sprinkler heads with 11/64th inch by 1/8th inch nozzles, two sprinkler heads with no nozzles (!) and 1 sprinkler head with a single 11/64th inch nozzle. The sprinkler heads are spaced 40 feet between the pipelines and 60 feet on the pipelines. Mr. Facey indicated that future plans are to replace the sprinkler system with drip irrigation. **HOWEVER, IN THE MEANTIME, IT IS RECOMMENDED BY THE CONSULTING IRRIGATION ENGINEER THAT THE LATTER ABOVE 3 SPRINKLER HEADS BE REPLACED WITH SPRINKLER HEADS HAVING 11/64TH INCH BY 1/8TH INCH NOZZLES (ALL SPRINKLER HEADS WITH THE SAME SIZED NOZZLES) TO PROVIDE UNIFORM WATER APPLICATION ON THE ENTIRE BIRD OF PARADISE AREA. WITH THE SPRINKLER NOZZLES OPERATING AT 60 PSI (INDICATIONS ARE THAT AMOUNT OF PRESSURE IS AVAILABLE IN THIS AREA), A NET OF 1/3 OF AN INCH OF WATER IS APPLIED IN ONE HOUR OF IRRIGATION. IT IS ALSO RECOMMENDED THAT THE SPRINKLERS BE PLACED A SHORT DISTANCE TO THE SIDE OF THE BIRD OF PARADISE PLANTS. WITH THE SPRINKLERS LOCATED AMONGST THE PLANTS, SEVERAL OF THE SPRINKLER HEADS ARE UNABLE TO ROTATE. THE PLANTS ARE TALL ENOUGH TO KEEP THE SPRINKLER HEADS FROM ROTATING.**

DRIP IRRIGATION

The major irrigation system on the Jamaican Floral Exports farm is drip irrigation. A drip irrigation system is designed is to operated at 15 to 25 psi. The consulting Irrigation Engineer noted that the pressures in the shade houses and outside irrigated areas are much higher then the 15 to 25 psi required. **THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THAT A PRESSURE REGULATOR OR A PRESSURE GAUGE AND A SMALL BRASS GLOBE VALVE BE INSTALLED AT ALL DRIP IRRIGATION TURN ON STATIONS TO CONTROL THE PRESSURE PROPERLY. USING A GLOBE VALVE, PRESSURE CAN BE ADJUSTED TO WHATEVER IS DESIRED.**

A drip emitter is designed to apply one specific flow rate of water. Most commonly there is a choice between 0.5, 1.0, 1.5, and 2.0 gallons per hour (gph). Thus, it is very important to regulate the pressure which in turn determines the flow rate of each drip emitter. The Jamaican Floral Exports farm irrigation supervisor should consult a drip irrigation dealer to determine what the drip emitter pressure requirements are and the resulting water flow rates for each kind of emitters used on the farm. Knowing the flow rate of the drip emitters, the irrigation water application rate can be calculated. **FOR EXAMPLE: IF 200 ONE GALLON PER HOUR DRIP EMITTERS ARE OPERATING AT A TIME IN AN AREA, THAT IS EQUAL TO 200 GPH OR 3.3 GPM (200 GPH DIVIDED BY 60 MINUTES/HOUR = 3.3 GPM). 3.3 GPM IS EQUAL TO 0.007 ACRE-INCHES OF WATER APPLIED PER HOUR (FROM EARLIER DISCUSSION WHERE 450 GPM IS EQUAL TO 1 ACRE-INCH PER HOUR). TO APPLY AN ACRE-INCH OF WATER, IT WILL REQUIRE 142 HOURS OR 6 DAYS (24 HOURS/DAY) OF IRRIGATION. IF 200 GPM ARE AVAILABLE, ABOUT 3600 DRIP EMITTERS CAN BE OPERATING AT ONE TIME. A GOOD WAY TO DETERMINE WHEN ENOUGH IRRIGATION WATER HAS BEEN APPLIED TO AN AREA, USE THE IRON ROD AS DISCUSSED LATER IN THIS REPORT.**

JAMAICAN FLORAL EXPORTS STREAM WATER QUALITY

During the consulting Irrigation Engineer's visit to the Jamaican Floral Exports irrigation pumping site, the stream water was essentially crystal clear. Robert Facey, indicated that during high rainfall times, the stream carries large quantities of calcium silt particles (resulting erosion in the mountainous terrain where the stream is located). When operating the submersible irrigation pumping plant during the times when the water has a high load of silts, the submersible pump impellers and motor bearings wear very rapidly. Generally, the submersible pump and motor need to be completely replaced after about a year's operation. The submersible pump and motor are very susceptible to wear when pumping water carrying silts. The calcium silt particles are very abrasive and will cause rapid damage to a turbine type of pump and motor such as the submersible.

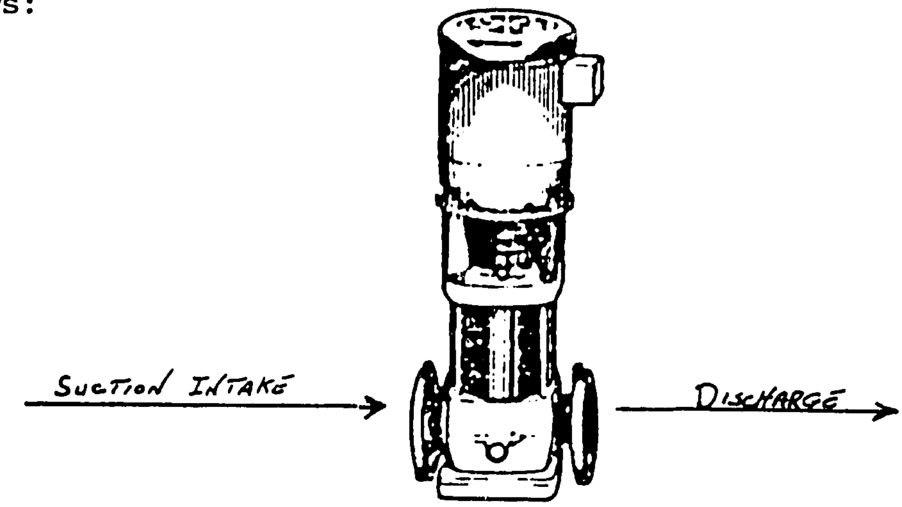
The preferred solution to the silt problem would be to eliminate the silt at the source using screens or constructing a settling pond. The silt load carried by the stream during high flow times, as indicated by Mr. Facey, virtually makes it impossible to build an adequate screening system or settling pond.

Mr. Facey has been considering a centrifugal pump as a solution to pumping the silty water. A centrifugal pump is installed above a stream surface level approximately 10 to 15 feet. In other words, the centrifugal pump pulls or sucks the water up into the pump. For the centrifugal pump to do this, it requires to be primed at the beginning of each start up (a disadvantage of this type of pump). The limit of a centrifugal pump is 10 to 15 feet above the water surface for it to pull or suck the water up to its impeller. Thus, at high stream flow times, if the water level rises more then 15 feet, the centrifugal pump may not be the solution either. However, Mr Facey indicated at the present irrigation pumping site, the water level does not exceed the 15 feet of rise.

A centrifugal pump is designed to pump silty water more so then a turbine type of pump such as the submersible. Over time, there will be wear on the centrifugal impellers also, but not near as rapidly as the impellers in a submersible. The centrifugal is constructed such that it can pump "dirty" water. Wear may take place in the pump shaft bearing area, but the bearing is easily replaced at location.

THE CONSULTING IRRIGATION ENGINEER CONCURS WITH ROBERT FACEY'S IDEA OF INSTALLING A CENTRIFUGAL IRRIGATION PUMPING SYSTEM AND RECOMMENDS THAT ONCE THE PRESENT JAMAICAN FLORAL EXPORTS SUBMERSIBLE PUMP AND MOTOR NEEDS TO BE REPLACED, IT BE REPLACED WITH A CENTRIFUGAL PUMP AND MOTOR.

Mr. Facey is considering a Grundfos, Series C Multi-Stage Centrifugal pump, which can be purchased locally, is shown as follows:



CENTRIFUGAL PUMP

According to the pump performance curve (attached), the pump will deliver 108 gpm at a total head of 534 feet, rotating at 3525 revolutions per minute (rpm) - (follow the arrows on the pump performance curve). The efficiency of the pump is 71%, again shown on the pump performance curve. This is a bit less then the 75% for the submersible pump, discussed above. The tolerance or spacing between the centrifugal impeller and pump housing or casting is not as close as in the submersible turbine impellers. Thus, the decrease in efficiency. However, this also is the reason less wear results in a centrifugal pump when pumping silty water.

With the pump operating at 71% efficiency and the electric motor at 88% efficiency, the irrigation pumping plant efficiency will be 63% (0.71 x 0.88 = 0.63). Horsepower required to operate the centrifugal pump, using the formula discussed earlier is as follows:

$$\textbf{Horsepower (proposed centrifugal)} = \frac{108 \times 534}{3960 \times 0.63}$$

$$= 23$$

Kilowatt-hours required to operate the 23 horsepower motor are 17 (23 x 0.746 = 17).

Every farm the consulting Irrigation Engineer has visited to date, the management has indicated the Jamaican Electrical Utility Company has numerous electrical service interruptions. Mr Facey has plans to install a standby diesel engine to drive the centrifugal pump when the electrical power is off. This can be done. The fuel required to operate the irrigation pump while powered by the diesel engine will be 1.5 gallons per hour compared to the 17 kilowatt-hours for the electric motor.

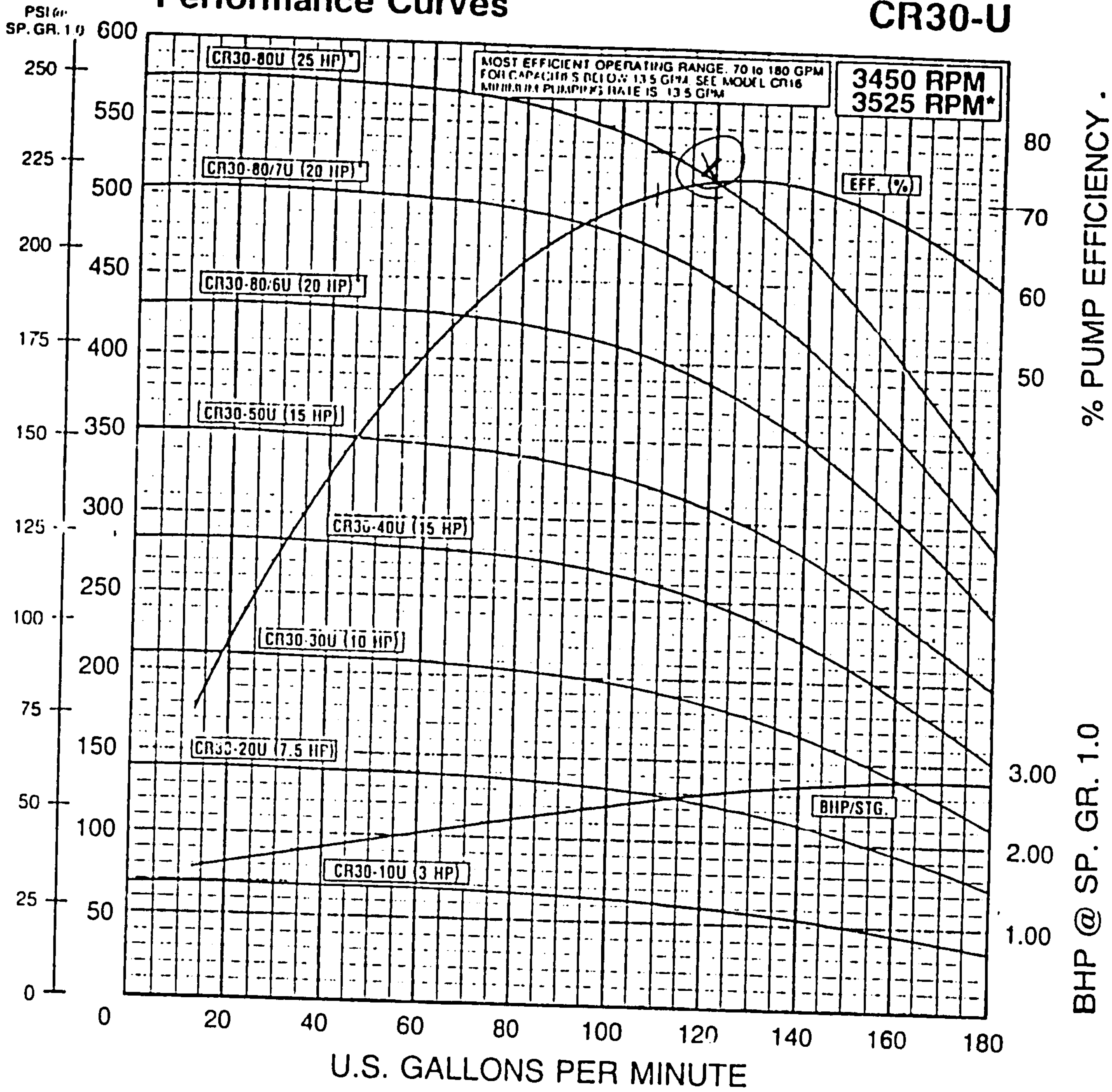
As indicated above, the Grundfos centrifugal pump will need to operate at 3525 rpm to provide 108 gpm at 534 feet of total head. With 50 cycle electricity, a 60 cycle 3525 rpm electric motor will rotate only at about 3000 rpm. Thus, the electric motor must be built at the factory for 50 cycle electricity to provide the 3525 rpm. If the 3525 rpm pump where slowed to 3000 rpm, it would deliver only about 85 gpm.

Also, a gear drive will need to be installed with the diesel engine to provide the necessary 3525 rpm for the pump.

THE CONSULTING IRRIGATION ENGINEER CONCURS THAT THE GRUNDFOS CENTRIFUGAL PUMP PLANT AS DISCUSSED ABOVE, WILL PROVIDE THE REQUIRED 100 GALLONS/MINUTE AND 534 TOTAL FEET OF HEAD, THE NECESSARY OPERATING CONDITIONS TO DELIVER THE IRRIGATION WATER REQUIRED FOR THE JAMAICAN FLORAL EXPORTS.

Performance Curves

CR30-U

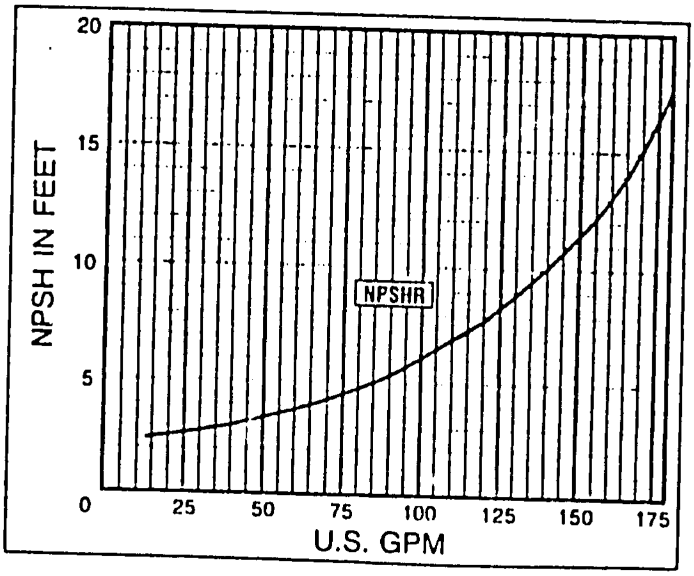


nstruction Materials

CRIPTION	MATERIAL
, impellers, diffuser chambers, outer p sleeve, impeller seal rings, and seal parts	AISI 304 SS
ion/discharge chamber, motor stool, motor coupling	Cast Iron
seal faces and intermediate bearing als	Tungsten Carbide
0 (10 – 50) rotating seal faces	Carbon
mediate chamber bearings	Alum. Oxide Ceramic
ngs	EPDM (Viton* – optional)
r sleeve gaskets	Non-Asbestos Fiber

EPDM - Ethylene Propylene Rubber
Viton* is a registered trademark of DuPont

NPSH Curve



DELIVERING WATER TO THE SHADE HOUSES

Water is siphoned from the holding pond to the shade houses through two 4 inch pvc pipelines. Gravity pressure in about the center of the shade house area (there being 15 shade houses of varying sizes) is 70 to 75 psi. One of the two 4 inch pvc pipelines looses it prime at times. The intake ends of the 4 inch pipelines are screened to keep out a major amount of the silt from entering the pipelines, silt which settles out in the pond from the water that is pumped from the stream (the silt is cleaned out of the pond about once a year). It was thought that the screen on the one 4 inch pipe may become clogged at times resulting in the lose of prime at times. In studying the piping in the shade houses, it was noted that one of the 4 inch lines is serving more shade house area then the other. It is likely that more water is drawn from this one 4 inch pipeline then what can flow in it, thus, causing it to lose prime at times. Six inch pvc pipe is available on the farm. Mr Facey had been contemplating replacing a portion of the 4 inch pipeline beginning from the pond and continuing down the hill for a distance. Approximate maximum water flow in various pipe sizes is shown as follows:

2 inch pipe: 40 to 60 gpm
3 inch pipe: 90 to 125 gpm
4 inch pipe: 200 to 300 gpm
6 inch pipe: 600 to 800 gpm

The flows will vary with the amount of pressure in the pipeline. However, the above flows can serve as a guide.

THE CONSULTING IRRIGATION ENGINEER CONCURS WITH MR. FACEY AND RECOMMENDS THAT A PORTION OF THE 4 INCH PVC PIPELINE THAT LOSSES PRIME AT TIMES, BE REPLACED WITH 6 INCH PVC PIPE. IT IS ALSO RECOMMENDED THAT A ONE FOOT SCREENED STAND PIPE BE ADDED TO THE INTAKE OF THE BOTH PIPELINES IN THE HOLDING POND.

SOME IRRIGATION PRINCIPLES

No matter which irrigation methods and practices are used, it is necessary for the irrigator to understand some basic principles about soils and plants in order to obtain maximum efficiency of the resources and, therefore, optimum production.

SOILS

The medium used to grow the Orchids is coconut husks. The orchids are hand watered, keeping the coconut husks wetted down as necessary. It is a very delicate operation and watering requirements and timing are made by visual observations are made by the irrigator to determine when watering is required.

The medium for all the other flowers and plants is soil as found on the Jamaican Floral Exports farm. The soil's most important function is to store water and nutrients for the plants. A soil's texture is the major factor affecting how much water it can hold for plant use. "Available water" refers to the amount of water that a soil can store and is accessible for plant use. Not all the water stored in the soil is available for the plant to use. Available water is the difference between field capacity (the most water the soil can hold in the plant root zone area) and permanent wilting point (soil water condition reached after the plant is unable to take any more water from the soil - the soil is not completely dry, but the plant is unable to take any more water from the soil).

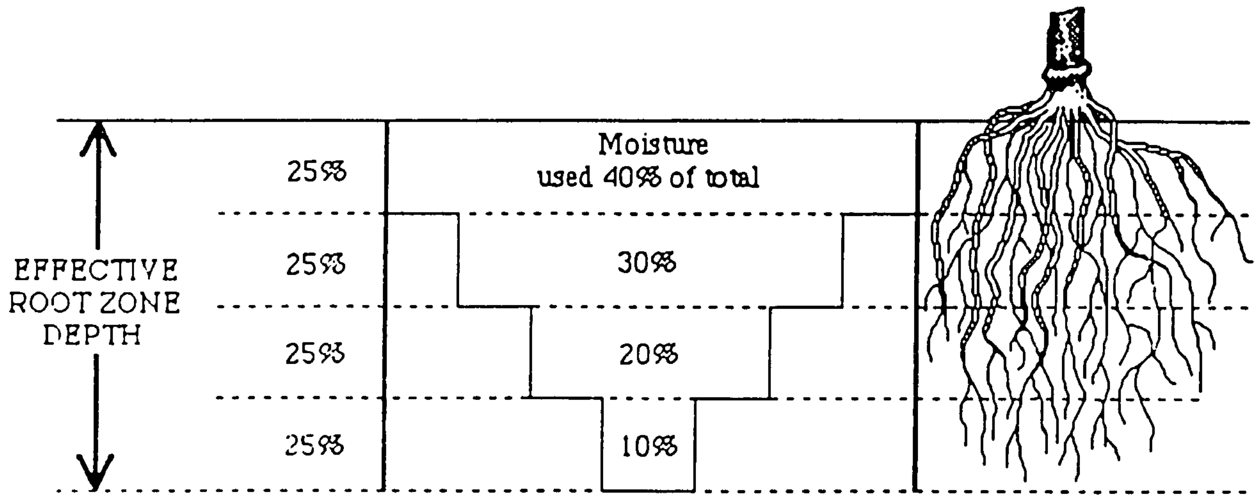
The following table shows the "available water" for plant use for different soil textures:

SOIL TEXTURE	AVAILABLE WATER (INCHES/FOOT OF SOIL)
SANDY	0.5
SANDY LOAM	1.0
LOAM	1.6
CLAY LOAM	2.0
CLAY	1.8

On the Jamaican Floral Exports farm, the soils are a loam in texture, thus hold 1.6 inches of available water for plant use when at field capacity (filled with water).

PLANTS

The roots of the plants are in contact with the soil and feed the plants with water and nutrients as available in the soil. Root depths vary by crops. Root depths for flowers such as Anthuriums, Birds of Paradise and Gingers are found mostly in the top foot of the soil area - a small amount of the roots may find their way to a bit deeper depth. The Ruscus plant roots may go a bit deeper then one foot, but mostly in the top 18 inches of soil. About 70% of all the plant roots are located in the top half of the root zone. Accordingly, the plant takes 70% of its water and nutrient needs from its top half of the root zone. **Thus, the Anthuriums, Birds of Paradise and Gingers will take their water supply and nutrient needs from about the top 9 or so inches and Ruscus from about 12 inches.** The distribution of the plant roots as found in the soil is approximately as shown in the following figure:



PLANT ROOT DISTRIBUTION IN THE SOIL

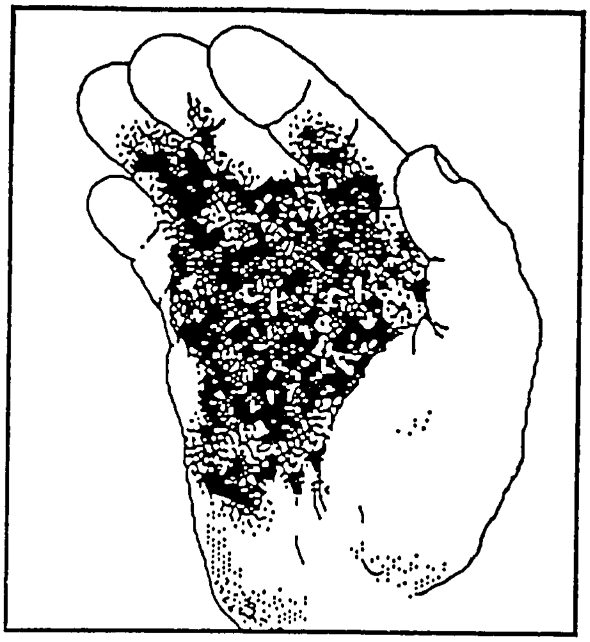
DEPTH OF IRRIGATION

In applying irrigation water, the goal is to fill the soil with water in the entire root area and no more. Even though 70% of the water is taken by the plant from the top half of the effective root area, irrigation water should still be applied throughout the entire plant root depth. **APPLY IRRIGATION WATER TO A DEPTH OF 12 INCHES FOR THE ANTHURIUMS, BIRDS OF PARADISE AND GINGERS AND AROUND 18 INCHES FOR RUSCUS.**

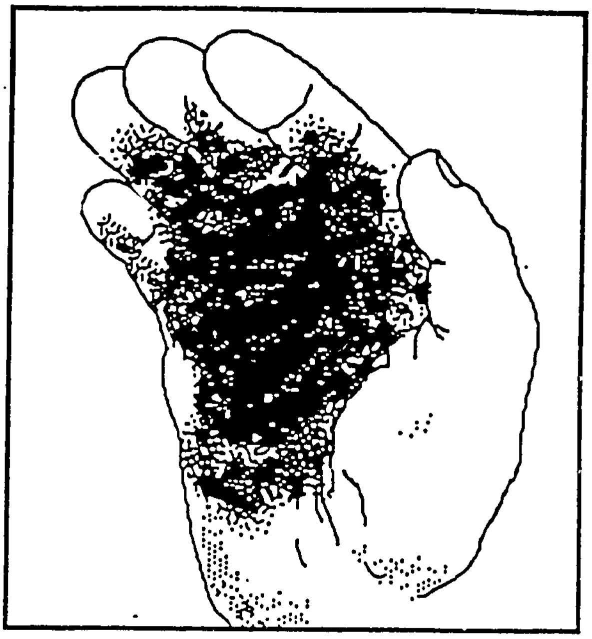
IRRIGATIONS SHOULD BEGIN WHEN 50% OF THE AVAILABLE WATER HAS BEEN DEPLETED FOR THE SOIL IN THE PLANT ROOT ZONE AREA. As indicated above, the soils on the Jamaican Floral Exports farm is a loam holding 1.5 inches of available water per foot of soil. Also, the root depths of the flowers are one foot. Thus, irrigation should begin after 0.75 inches of water has been depleted from the top foot of soil (1.5 x 0.50 = 0.75). For the Ruscus, using an 18 inch root depth, 2.25 inches of water are available to the plant. Thus, irrigation should begin after 1.1 inches of water have been depleted from the top 18 inches of soil (2.25 x 0.50 = 1.1).

FEEL AND APPEARANCE METHOD FOR DETERMINING AVAILABLE WATER

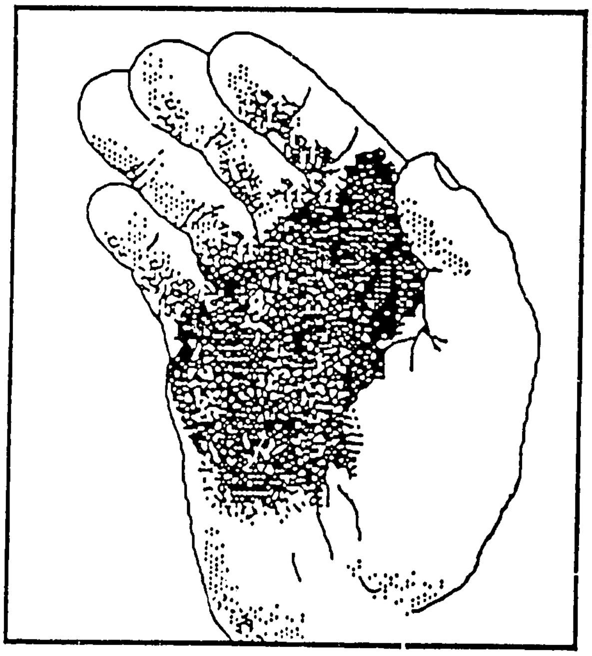
Available water remaining in the soil for plant use can be approximated by feeling and by the appearance of the soil. The irrigator needs to have a soil auger available to "pull" soil samples from different depths in the soil to feel it and determine available water remaining for plant use. Using the feel and appearance method to estimate the available water for a loam soil is illustrated in the following page. Also, a more detailed chart for using the feel and appearance method for estimating the available water is attached following the illustration page.



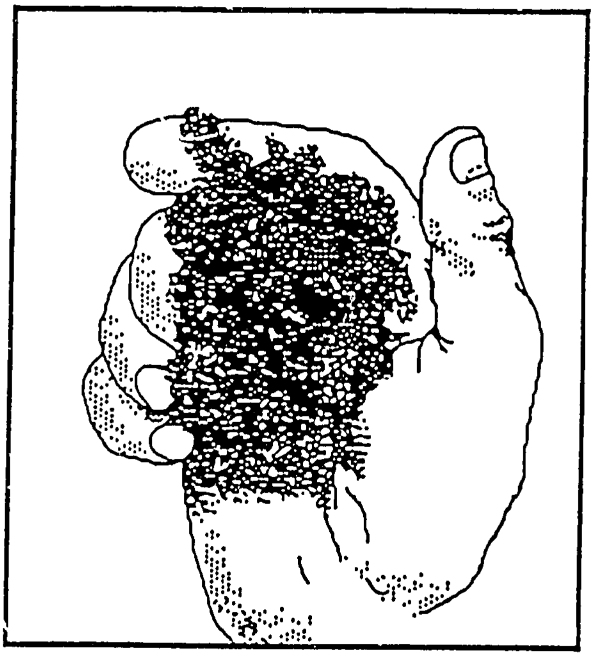
* 0 to 25% Available Moisture - Crumbles easily, tends to hold together from hand pressure.



* 25 to 50% Available Moisture - Somewhat crumbly, will hold together in hand with pressure.



* 50 to 75% Available Moisture - Forms "ball" readily, will "slick" slightly with pressure.



* 75 to 100% Available Moisture - Forms "ball" easily, fairly friable, "slicks" readily.

USING THE FEEL AND APPEARANCE METHOD FOR LOAMS AND SILT LOAMS TO ESTIMATE AVAILABLE WATER

FEEL AND APPEARANCE CHART FOR AVAILABLE MOISTURE IN THE ROOT ZONE

Percentage of Soil Moisture Remaining	Soil Texture			
	[Sands] (Loamy Sandy)	[Sandy Loams] (Fine Sandy Loams)	[Loams and Silt Loams] (Clay Loams)	[Silty Clays] (Clays)
0 to 25%	Dry, loose soil flows through fingers [0 to 0.20] (0 to 0.25)	Dry, loose soil flows through fingers [0 to 0.40] (0 to 0.50)	Powdery, dry, crusty [0 to 0.55] (0 to 0.55)	Hard, cracked [0 to 0.50] (0 to 0.50)
25 to 50%	Appears dry, will not form a ball with pressure. [0.20 to 0.40] (0.25 to 0.50)	Appears dry, forms very weak ball under pressure [0.40 to 0.75] (0.50 to 1.00)	Partly crumbly, forms ball under pressure [0.55 to 1.10] (0.55 to 1.10)	Partly pliable, forms good ball under pressure [0.50 to 0.95] (0.50 to 0.95)
50 to 75%	Appears dry, forms very weak ball under pressure [0.40 to 0.60] (0.50 to 0.75)	Almost dry, tends to form a crumbly ball under pressure [0.75 to 1.10] (1.00 to 1.50)	Forms partly plastic ball, may slick with pressure [1.10 to 1.65] (1.10 to 1.65)	Forms ball and will ribbon [0.95 to 1.45] (0.95 to 1.45)
75 to 100%	Tends to stick, forms weak crumbly ball [0.60 to 0.80] (0.75 to 1.00)	Forms weak ball, will not stick [1.10 to 1.50] (1.50 to 2.00)	Forms very pliable ball and may stick [1.65 to 2.20] (1.65 to 2.20)	Easily ribbons and has slick feeling [1.45 to 1.90] (1.45 to 1.90)
100%	The soil is at field capacity. Upon squeezing, no free water appears on the soil, but a wet outline of the ball is left in the hand.			

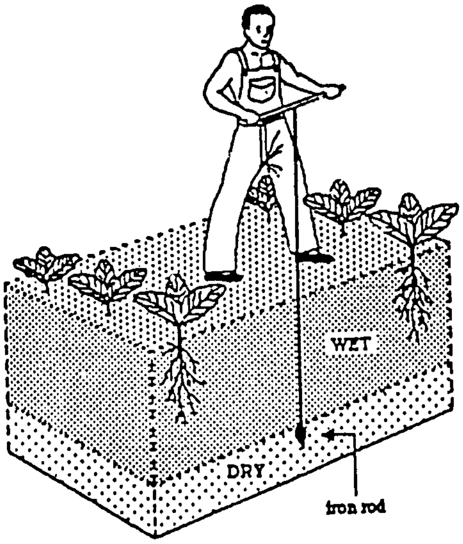
NOTE: Figures in each parentheses show inches of water available moisture remaining per foot of depth.

Take soil samples to a depth of 9 inches throughout the area in the flowers and to a 12 inch depth for Ruscus. For a loam soil, when squeezing and feeling the soil samples and it is somewhat crumbly, yet will hold together when applying pressure when squeezing the soil in the palm of the hand, about 50% of the available water has been depleted from the plant root area. Then irrigation should begin.

IRRIGATIONS SHOULD BE STOPPED WHEN IRRIGATION WATER HAS REACHED A DEPTH OF 12 INCHES OR SO IN THE SOIL WHEN IRRIGATING THE FLOWERS AND 18 INCHES FOR RUSCUS (DEPTH OF THE ROOTS AS DISCUSSED ABOVE).

A way to determine how deep the irrigation water has gone in the soil, an irrigator can use an iron rod. The iron rod is 3/8 inch in diameter and 3 feet in length with an enlarged tip or end. In wet soil, the rod will push into the soil very easily. When the tip or end of the rod reaches dry soil, it will push harder when continuing to push it. The point at which the rod begins to push harder is the line between the wet and dry soil. Thus, using the rod for the flowers, once the irrigation water has reached a depth of 12 inches for the flower and 18 inches for the Ruscus, irrigation can be stopped.

Using the iron rod is shown in the following figure:



USING AN IRON ROD

There are limitations where the iron rod can be used. In gravelly or very course soils, where there are rocks present in the soil profile, it may not be possible to push the iron rod into the soil. The soil auger, used for taking soil samples as discussed above, may need to be used in such kinds of soils. Even the soil auger may be difficult to use in gravelly, coarse soils. But it doesn't appear the soils on the Jamaican Floral Exports farm will be any problem for using the iron rod.

The iron rod is not commercially available. It can easily be made in a welding shop using 3/8 inch rod and welding a "T" on one end for a handle and a 1/2 inch ball bearing on the other end as the enlarged tip or end.

RAINFALL

Mean rainfall in Jamaica and at the Jamaican Floral Exports farm will exceed the water needs of the plants on the farm. However, not all the rainfall is effective or not all enters the soil. Rainfall intensities at times are such that the soils are unable to absorb all the rainfall, causing runoff. The shades over the Orchids let no rain through them because watering is most critical for these plants. Shades over the remaining plants and on the outside or open areas, all the rain water reaches the ground. The effective rainfall or the amount that enters the soil, will vary with each rainfall. **IT MAY BE WELL TO LOCATE RAIN GAUGES IN THE SHADE HOUSES, (NOT ORCHIDS) AND IN THE OPEN AREAS WHERE THE FLOWERS ARE GROWN.** Even though the rain gauges will not measure the effective rainfall, it is still good to have rainfall records.

After a rain, the iron rod, as discussed above can be used to determine how deep the rain water has penetrated the soil.

Regardless, feeling the soil and noting its appearance periodically will still be necessary to determine when irrigations should take place.

ADDITIONAL WATER EQUIVALENTS

ONE CUBIC FOOT OF WATER = 7.5 GALLONS
ONE CUBIC FOOT OF WATER = 62.4 POUNDS
ONE CUBIC FOOT PER SECOND (CFS) = 450 GALLONS/MINUTE
ONE MILLION GALLONS OF WATER = 3.1 ACRE-FEET

SUMMARY RECOMMENDATIONS

* **WHEN PRESENT SUBMERSIBLE IRRIGATION PUMPING PLANT NEEDS TO BE REPLACED, INSTALL A CENTRIFUGAL IRRIGATION PUMP.**

* **DEALER TO PROVIDE THE CLIENT WITH A PUMP PERFORMANCE CURVE FOR THE CENTRIFUGAL PUMP INSTALLED.**

* **INSTALL PIPELINE WATER FLOW METER.**

* **INSTALL 11/64TH INCH x 1/8TH INCH NOZZLES IN THOSE SPRINKLER HEADS THAT NOW HAVE DIFFERENT SIZED NOZZLES OR NO NOZZLES.**

* REPLACE PORTIONS OF THE 4 INCH PVC PIPELINE THAT AT TIMES NOW LOSSES IT PRIME WITH 6 INCH PVC TO DELIVER THE WATER FROM THE HOLDING POND.

* ADD A ONE FOOT SCREENED STAND PIPE TO BOTH INTAKES OF THE PIPELINES IN THE HOLDING POND.

* PRESSURE REGULATORS OR A PRESSURE GAUGE AND A SMALL BRASS GLOBE VALVE BE INSTALLED AT ALL DRIP IRRIGATION TURN ON - TURN OFF POINTS TO PROVIDE THE RECOMMENDED PRESSURE FOR THE DRIP EMITTERS.

* MAY WANT TO INSTALL RAIN GAUGES IN EACH OF THE SHADE HOUSES, OTHER THEN THE ORCHID SHADE HOUSES, AND ONE IN THE OUTSIDE IRRIGATED FLOWER AREAS.

* A SOUL AUGER BE MADE AVAILABLE TO THE IRRIGATION SUPERVISOR.

* AN IRON ROD BE MADE AVAILABLE TO THE IRRIGATION SUPERVISOR.

* SCHEDULE IRRIGATIONS WHEN 50% OF THE AVAILABLE WATER HAS BEEN DEPLETED FROM THE PLANT ROOT ZONE AREA.

* APPLY IRRIGATION WATER UNTIL SOIL IS AT FIELD CAPACITY IN THE PLANT ROOT ZONE.

POND ALGAE GROWTH

Mr. Facey indicated a problem at times in the holding pond is algae growth. The algae problem can be solved by using copper sulfate. A container of copper sulfate can be place so water flowing into the holding pond from the irrigation pumping plant flows through the container of copper sulfate. The water dissolves the copper sulfate and mixes with the pond water killing algae growth. **HOWEVER, BEFORE COPPER SULFATE IS USED, CONSULTATION IS REQUIRE FROM SOMEONE OTHER THEN THE CONSULTING IRRIGATION ENGINEER WHETHER COPPER SULFATE IS TOXIC TO THE FLOWERING PLANTS OR NOT.**

IRRIGATION MANAGEMENT

The consulting Irrigation Engineer spent time with Mr. Michael Peart, Operations Manager and Mr. Vinney Williams, Irrigation Supervisor. These two are very knowledgeable individuals in the Jamaican Floral Exports irrigation required operations. Time was spent with them discussing soils, soil water holding capacities, scheduling irrigations using the feel and appearance method, using the iron rod to determine depth of irrigation, etc.

GREEN VALLEY JAMAICA LTD.

ST. MARY

HARMONY HALL, JAMAICA

IRRIGATION REPORT

APRIL 3, 1995

DONALD J. BROSZ
CONSULTING IRRIGATION ENGINEER

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT

CHEMONICS INTERNATIONAL CONSULTING DIVISION
WASHINGTON, D.C.

GREEN VALLEY JAMAICA LTD.

ST. MARY

HARMONY HALL, JAMAICA

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT IRRIGATION SCOPE OF WORK

* The consulting Irrigation Engineer will spend one day on the farm making a preliminary assessment of the irrigation needs of the Client's farm.

* Consulting Irrigation Engineer to provide the Client with a report outlining the results of the work and make recommendations to the Client with respect to irrigation.

GREEN VALLEY JAMAICA FARM IRRIGATION PLANNING RECOMMENDATIONS

FARM IRRIGATION SYSTEM PLANNING AND OPERATION

* Consult with a Vegetable Specialist to determine what vegetables can and can not be grown in heavy soils.

* Consult with water resource authorities in Jamaica to obtain information regarding quantity and quality of water available in the stream which is proposed to be used as the irrigation water source.

* Acquire elevations for the farm to determine lift and distance water has to be pumped, information required to select an efficient irrigation pumping plant and adequate mainline delivery pipe size.

* A centrifugal irrigation pumping plant be used for pumping stream surface water.

* A pipeline water flow meter and pressure gauge be purchased as part of the irrigation pumping plant.

* Select the size of delivery mainline pipe for maximum flow and total lift.

* Concur that drip irrigation be selected as the irrigation system on the farm.

* Obtain at least two draft irrigation system designs and cost estimates from local irrigation dealers with alternatives of dealer to install the irrigation system or dealer to supervise installation of the irrigation system.

* Provide Farm Irrigation Supervisor with necessary equipment to effectively and efficiently carry out the duties of irrigation management and operation on the farm such as a soil auger and iron rod.

* Construct a one acre-foot water holding pond which equal to 326,000 gallons.

IRRIGATION SYSTEM PLANNING REPORT

GREEN VALLEY JAMAICA LTD.

HARMONY HALL, JAMAICA

APRIL 3, 1995

INTRODUCTION

Green Valley Jamaica Ltd. is a private limited liability company involved in the production and marketing of fresh produce. The firm is owned by the Brown family with Ms. Tanya Brown as Managing Director. The farm began operating on the 120 acres of land in the St. Mary's parish in early 1994. It's primary goal is to develop a reputation for delivering high quality fresh fruit and vegetables to export markets.

There is no irrigation on Green Valley at the present time. Ms. Brown indicated that the immediate plans are to irrigate 40 acres of vegetables with benefits from irrigating the vegetables also be realized by the new planting of soursop plantings (vegetables to be planted amongst the soursop).

The planned irrigation water source is surface water from a stream that borders a portion of the farm's land area. The major soil type on the farm is clay loam to clay.

GREEN VALLEY FARM IRRIGATION PLANNING PROCESS

SOILS

As indicated, the Green Valley farm soils are clay loams to clay in texture. From the consulting Irrigation Engineer's past experiences and observations, many vegetables do not grow well nor produce well in heavy types of soils. However, the consulting Irrigation Engineer is not qualified to make such recommendations. **ONE OF THE VERY FIRST STEPS THAT NEEDS TO BE TAKEN IS TO CONSULT WITH A HORTICULTURALIST (VEGETABLE SPECIALIST) TO DETERMINE WHAT VEGETABLES CAN AND CAN NOT BE GROWN ON HEAVY TYPE SOILS.**

AVAILABLE WATER RESOURCES FOR THE PLANNED IRRIGATION PROJECT

Plans are to pump the irrigation water from a stream which borders a portion of the farm. During the consulting Irrigation Engineer's visit to Green Valley, the stream flow was observed and noted that the flow was very small. At this time of year, Ms. Brown indicated flow is generally always very small. The consulting Irrigation Engineer during his professional career has never made a visual estimate of quantity of flows in a stream. It is virtually impossible to do because many factors are involved in measuring water flow in a stream, thus difficult to do visually.

ANOTHER ONE OF THE FIRST STEPS IS TO OBTAIN INFORMATION REGARDING QUANTIFY OF WATER AVAILABLE IN THE STREAM AT VARIOUS TIMES OF THE YEAR FOR IRRIGATION ON GREEN VALLEY. INFORMATION ON QUANTITY OF WATER AVAILABLE FOR IRRIGATION IS NEEDED FOR DESIGNING AN EFFICIENT IRRIGATION PUMPING PLANT, FOR DESIGNING THE SIZE OF DELIVERY PIPES NEEDED AND TO DETERMINE THE AMOUNT OF AREA THAT CAN BE ADEQUATELY IRRIGATED.

The consulting Irrigation Engineer has located a Jamaican Government hydrology group, the Underground Water Authority that collects both surface and groundwater data. The Underground Water Authority water quantity and quality data is made available to the land owner upon request at nominal cost.

A private Kingston hydrology consulting firm was also located by the consulting Irrigation Engineer. Mr. Michael White, Managing Director/Hydrogeologist, Hydrology Consultants, Ltd., Kingston provides on farm services such as assessing the quantity and quality of the water resources available from surface and/or groundwater. His firm also provides a service where they address the issues of how best to develop the farm's water resource(s) - drilling a well, constructing storage, pumping method, type of pump to use, best pumping site for the surface supply, etc.

The consulting Irrigation Engineer similar private consultants are available in Jamaica that can provide similar water resources and development services. The consulting Irrigation Engineer is not necessarily recommending the above mentioned Hydrology Consulting Firm.

THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THAT MS. BROWN VISIT WITH THE UNDERGROUND WATER AUTHORITY TO INQUIRE AND ACQUIRE WHATEVER, IF ANY, AVAILABLE WATER FLOW QUANTITIES AND WATER QUALITY DATA RELATING TO THE STREAM BORDERING GREEN VALLEY. ALSO, MS. BROWN MAY WANT TO INQUIRE WITH A PRIVATE CONSULTING FIRM SUCH AS HYDROLOGY CONSULTANTS, LTD., EXACTLY WHAT SERVICES AND WATER RESOURCE INFORMATION THAT THEY CAN PROVIDE SPECIFICALLY FOR GREEN VALLEY AS THEY RELATE TO THE GREEN VALLEY IRRIGATION PLANS AND AT WHAT COST. THE COST OF A PRIVATE CONSULTING FIRM MAY PROVE TO BE ECONOMICAL IN THE LONG RUN IF THEY CAN PROVED SPECIFIC WATER RESOURCES DATA AND INFORMATION FOR GREEN VALLEY.

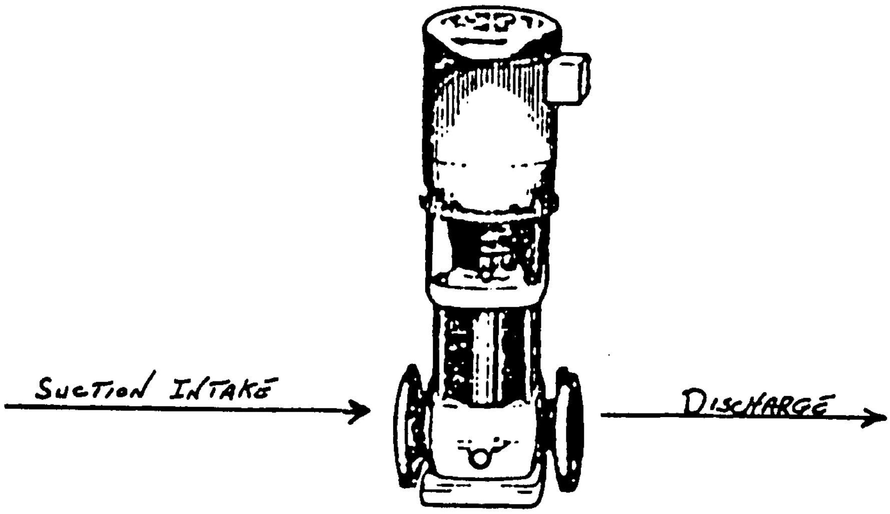
IRRIGATION PUMPING PLANT

When pumping surface water for irrigation, a centrifugal pump should be considered. Surface water generally carries silts. Silts in the water cause wear to the pump impellers and bearings. A centrifugal pump is built to pump silty water more so then pumps used for pumping water from wells. This is not saying that there will be no wear on a centrifugal pump when pumping silty water, but will be less than with water well (turbine) type pumps.

One disadvantage of a centrifugal pump is that it needs to be primed each time it is started up to pump water. However, devises are available to easily prime the pump.

The centrifugal pump suction side or intake should be located as closely to the stream surface as possible for most efficient operation of the pump. Yet, the pump should be located above the expected flood stage of the stream. Most centrifugal pump manufacturers recommend that the pump should be located 15 feet or less above the stream water surface.

A typical centrifugal irrigation pumping unit is shown in the following figure:



CENTRIFUGAL PUMP

The above figure shows the centrifugal pump being driven by an electric motor. The pump can also be driven by an internal combustion engine such as a diesel engine.

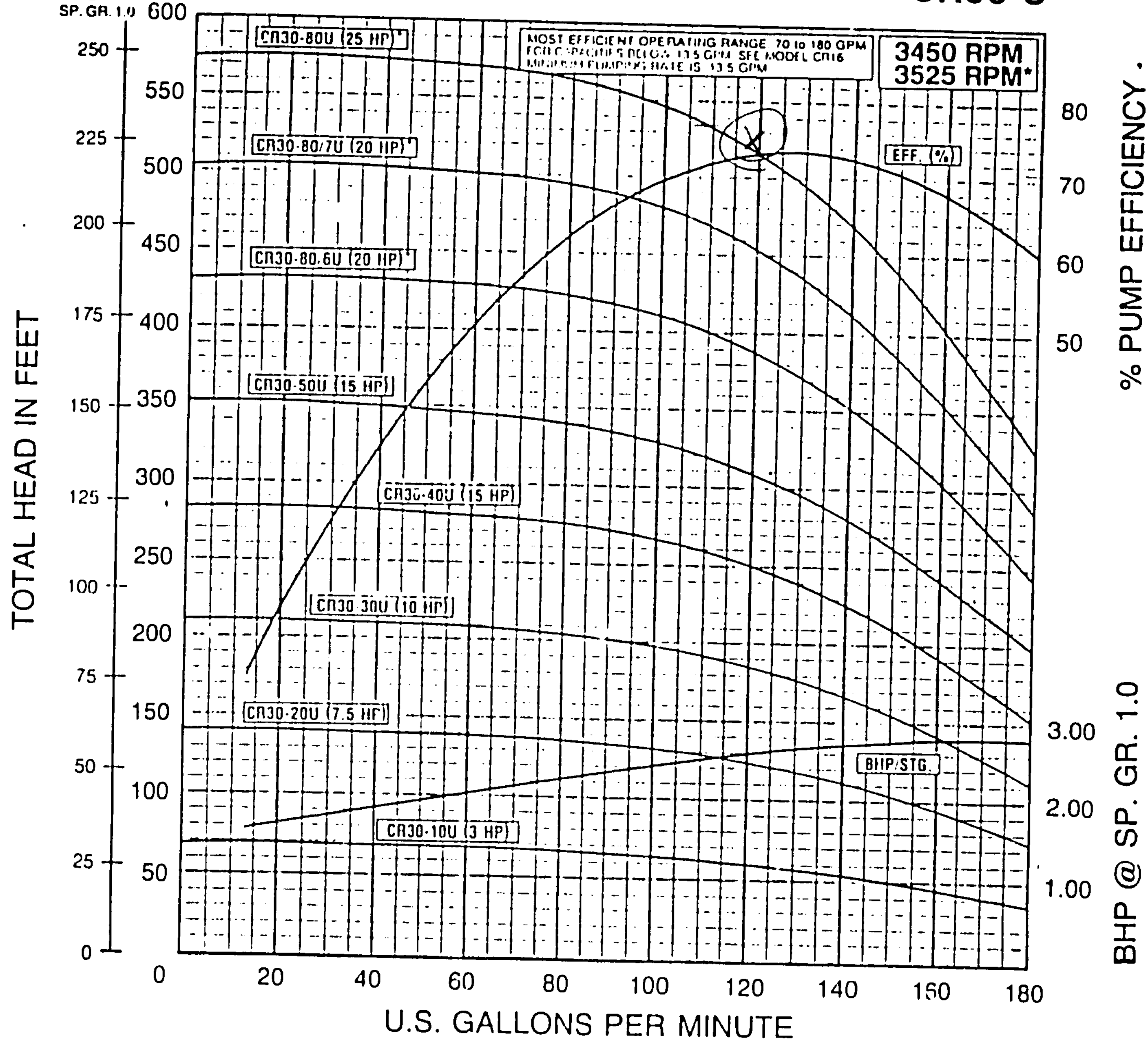
THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THAT GREEN VALLEY GIVE PRIORITY TO A CENTRIFUGAL TYPE IRRIGATION PUMP FOR ITS IRRIGATION PUMPING PLANT.

Irrigation pump manufacturers have a performance curve for every model of pump they manufacture. A pump should be selected on the basis of the pump performance curve. An example of a pump performance curve is attached on the following page.

Referring to the pump performance curve attached, note the amount of water in U.S. gallons per minute (gpm) this particular pump will produce as shown across the bottom of the curve, the total head in feet it will produce as shown on the left vertical side of the

Performance Curves

CR30-U

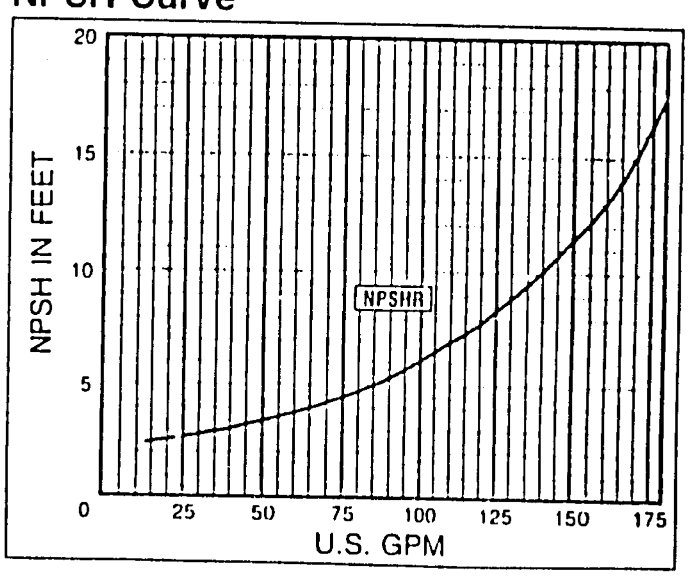


Construction Materials

DESCRIPTION	MATERIAL
Shaft, impellers, diffuser chambers, outer pump sleeve, impeller seal rings, and shaft seal parts	AISI 304 SS
Suction/discharge chamber, motor stool, and motor coupling	Cast Iron
Shaft seal faces and intermediate bearing journals	Tungsten Carbide
CR30 (10 – 50) rotating seal faces	Carbon
Intermediate chamber bearings	Alum. Oxide Ceramic
O-rings	EPDM (Viton* – optional)
Outer sleeve gaskets	Non-Asbestos Fiber

NOTES EPDM - Ethylene Propylene Rubber
Viton* is a registered trademark of DuPont

NPSH Curve



curve, the pump efficiency is shown on the upper left vertical side of the curve and the performance curve for each available pump impeller and the required brake horsepower noted on each of the performance curves. Also, in the upper right hand corner, it is noted at what speed(s) the pump must rotate to do what is noted on the performance curves. The "x" marked on the performance curve (marked by the consulting Irrigation Engineer) indicates the conditions where this particular pump operates most efficiently.

Dropping straight down from the "x" mark, it shows this pump with a CR30-80U impeller will pump 120 gpm to about 140 gpm at a total head of 510 to 520 feet (straight across to the left), at an efficiency of 70 to 74% (straight across to the right), requiring 25 brake horsepower (designated on the curve) while operating at 3525 revolutions per minute (rpm). Following the same procedure as above, if this CR30-80U pump impeller were used to pump 180 gpm, it would do this only at 320 feet of total head at an efficiency of 60%, operating at a speed of 3525 rpm.

Total head in feet includes the vertical distance water has to be lifted (vertical difference from the water surface of the stream surface to the point where water is discharged like into a pond) and friction loss in the pipeline used to deliver the water, all measured in feet. Thus, it is very important that the exact vertical lift and exact pipe friction is known before the selection of the most efficient pump can be made. Efficiency of a pump is an indicator as to the ability of the pump to deliver a certain quantity of water at a required total lift using the least amount of energy (horsepower).

Where a centrifugal pump is pumping irrigation water from a stream, consideration should be given to selecting a high efficient pump over a range of water pumping capacities. The example pump performance curve, as indicated above, has a high efficiency over a range of 120 to 140 gpm. Centrifugal pumps are available having even a larger pumping range and yet operate at a high efficiency. The reason for selecting a pump that has a high efficiency over a relatively large range of pumping capacities, is when the stream flow is high, an irrigator may want to pump more water than can be pumped during low stream flows.

ONCE A PUMP HAS BEEN SELECTED, THE PUMP DEALER MUST PROVIDE THE PUMP PERFORMANCE CURVE TO THE OWNER FOR KEEPING THE IRRIGATION SYSTEM FILE FOR FUTURE REFERENCE.

Once the vertical lift has been determined by a land surveyor or, if available, from a topographical map of the Green Valley farm, it can be determined if one or two irrigation pumping plants are required. If a centrifugal pump can be selected that can pump the required amount of water for the total vertical lift, then only one pumping plant may be required. If one pumping plant is unable to meet the conditions, the one irrigation pumping plant may be required to pump the water up the hill about half way and release the water into a holding pond and another irrigation pumping plant to pump the water from the holding pond up the remaining distance and again release the water into a second holding pond. **IT IS THE FEELING OF THE CONSULTING IRRIGATION ENGINEER THAT ONLY ONE CENTRIFUGAL IRRIGATION PUMPING PLANT AND ONLY ONE HOLDING POND WILL BE REQUIRED. CENTRIFUGAL PUMPS ARE AVAILABLE WHICH WILL DELIVER WATER THE HEIGHT AND DISTANCE AS REQUIRED FROM THE STREAM TO THE HIGH POINT OF THE GREEN VALLEY FARM. IT WILL BE MUCH LESS EXPENSIVE TO DELIVER WATER TO DISTANT AREAS OF THE FARM BY PIPING AND GRAVITY FLOW.**

Ms. Brown indicated that a diesel engine will be used to power the pump. Generally, the diesel drive shaft does not rotate at the necessary speed that a pump must rotate. In such situations, a gear drive is installed between the engine drive shaft and pump drive shaft that provides the necessary speed to the pump.

PUMP ROTATION SPEED VS PUMP CAPACITY

As indicated above, when pumping water from a stream, an irrigator may have the opportunity to pump more water during high stream flows and having to decrease the pumping rate during low stream flows. With an internal combustion engine, the rpm's can be varied and thus, the pump rpm's can also be varied. The pump discharge for varying rpm's can be calculated using the following formula:

$$\text{GPM @ ADJUSTED RPM} = \frac{\text{ADJUSTED PUMP RPM} \times \text{DESIGNED PUMP GPM}}{\text{DESIGNED PUMP RPM}}$$

For example, if the irrigation pumping plant has been designed to pump 250 gallon/minute at 3450 rpm, what would the pump discharge if it were operated at 2800 rpm?

$$\text{GPM @ 2800 RPM} = \frac{2800 \times 250}{3450} = 203$$

At the new pump rpm of 2800, the pump would now pump 203 gpm. It may be necessary to have this option available to adjust the pump discharge with water available in the stream.

HORSEPOWER REQUIRED

As indicated above, the brake horsepower required to operate the pump at a certain pumping rate and total feet of head, is generally designated on the pump performance curve. However, brake horsepower required can also, be calculated by using the following formula and often more accurate then shown on the performance curve:

$$\text{HORSEPOWER (HP)} = \frac{\text{GALLONS/MINUTE BEING PUMPED} \times \text{TOTAL LIFT IN FEET}}{3960 \times \text{PUMP EFFICIENCY}}$$

For example, if the pump is discharging 250 gpm at a total lift of 300 feet (again, total lift is the vertical distance from water surface to discharge end of the pipe and friction in the pipeline), and the pump operating at an efficiency of 70%, what is the required brake horsepower under such conditions?

$$HP = \frac{250 \times 300}{3960 \times 0.70}$$

$$= 27 \text{ BRAKE HORSEPOWER}$$

FUEL REQUIREMENT

THE PERFORMANCE STANDARD FOR A WELL MAINTAINED DIESEL ENGINE IS 15 BRAKE HORSEPOWER HOURS PER GALLON OF DIESEL FUEL. TWENTY SEVEN BRAKE HORSEPOWER WILL USE 1.8 GALLONS PER HOUR (27 / 15 = 1.8).

To calculate diesel fuel requirement, divide brake horsepower by the performance standard of a diesel engine (15 brake horsepower per gallon of fuel).

MEASURING DEVICES

Two measuring instruments on an irrigation pumping plant which can be valuable water management tools to the irrigator are a pressure gauge and pipeline water flow meter installed in the discharge pipe of the pump. The pressure gauge should be installed in the pump discharge pipe near the irrigation pumping plant. The pipeline flow meter can be installed at in the pump discharge pipe where it is convenient to read. As daily or periodic readings are made of these two measuring instruments, accurate quantity of irrigation water delivered and available can be determined. Very important also is the irrigator can note changes that may occur in the instrument readings, especially when such readings begin to decrease. This indicates that problems may be developing in the irrigation pumping plant such as pump wear.

THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THAT A PRESSURE GAUGE AND A PIPELINE WATER FLOW METER BE INSTALLED ON THE IRRIGATION PUMPING PLANT AND BE PROPERLY MAINTAINED. THE PRESSURE GAUGE SHOULD BE REPLACED ABOUT EVERY 5 YEARS BECAUSE OF WEAR. IF SILTS ARE PRESENT IN THE WATER PUMPED, THE PIPELINE WATER METER SHOULD BE INSPECTED ONCE A YEAR BY AN EXPERIENCED IRRIGATION MAINTENANCE PERSON.

THE CONSULTING IRRIGATION ENGINEER ALSO RECOMMENDS A CHECK VALVE WHICH CLOSES BY WATER PRESSURE, SHOULD ALSO BE INSTALLED NEAR THE PUMP DISCHARGE TO HOLD THE WATER IN THE DISCHARGE PIPELINE FROM DRAINING BACK INTO THE STREAM AFTER THE IRRIGATION PUMPING PLANT IS SHUT DOWN.

HOLDING POND(S)

The holding pond size should be large enough to hold an acre-foot of water (essentially a one day's supply). If two holding ponds are required, both ponds should be constructed to hold an acre-foot of water. **AN ACRE-FOOT OF WATER IS EQUAL TO 326,000 GALLONS (U.S.). ONE CUBIC FOOT OF WATER IS EQUAL TO 7.5 GALLONS. THUS THE SIZE OF POND NEEDS TO BE 43,467 CUBIC FEET IN SIZE OR A POND SOMETHING LIKE 75 FEET LONG, 75 FEET WIDE AND 8 FEET DEEP.**

The Green Valley soils are clay loam to clay in texture. The soils may be heavy enough in texture to naturally seal the sides and bottom of the pond(s) so no or a very small amount of the water will leak from the pond(s). Pumping the water the distance and height as on the Green Valley farm will be expensive. It will be desirable to have a well sealed pond(s) to eliminated as much water loss as possible. If excessive water leaks from the pond(s), a butyl liner may need to be installed. Water Saver company in the U.S. is a major manufacturer of pond liners.

QUANTITY OF WATER TO BE PUMPED

Ms. Brown indicated that about 40 acres of land are planned to be developed with drip irrigation with close spaced crops such as vegetables. Thus, essentially all the land area will be irrigated as opposed to wider spaced crops such as fruit trees, etc. If one acre-foot (same as 12 acre-inches) of irrigation water is made available per day, this is enough water to apply 1/3 of an inch of water on each acre of land each day (gross). The net amount of water applied per acre will be a bit less because of some water losses.

RULE OF THUMB. PUMPING 450 GALLONS/MINUTE IS EQUAL TO 1 ACRE-FOOT (12 ACRE-INCHES) OF WATER IN TWELVE HOUR. DURING THE HIGHER FLOWS OF THE STREAM, 450 GALLONS/MINUTE MAY BE AVAILABLE FOR PUMPING (THE REASON THAT STREAM FLOW DATA NEEDS TO BE OBTAINED FOR DESIGNING A PUMPING PLANT). DURING THE DRIER MONTHS, LESS WATER MAY BE AVAILABLE FOR PUMPING AND PUMP RPM'S CAN BE CONTROLLED TO PUMP ONLY THE AMOUNT OF WATER AVAILABLE IN THE STREAM. IF PUMPING HAS TO BE CUT BACK TO 225 GPM, THEN IT WILL REQUIRE 24 HOURS OF PUMPING PER DAY TO SUPPLY ONE ACRE-FOOT OF WATER EACH DAY (450 / 2 = 225 AND HAVING TO PUMP TWICE AS LONG).

DISCHARGE PIPE SIZE

A 4 inch pvc pipe will have a friction loss of 102 feet in 1000 feet of pipe (taken from a pipe friction table, which all pipe dealers have available to them) when pumping 450 gpm. A six inch pvc pipe will have a friction loss of only 14 feet in 1000 feet of pipe when pumping 450 gpm. Again, it is very important to know how much water is available for pumping and also the length of pipeline needed. If only a maximum of about 300 gpm is available for pumping at high stream flows, then 4 inch pvc pipe is adequate.

Total lift in feet is also needed to determine the strength of pipe that is needed to carry the water and pressure without bursting. PVC pipe is rated as schedule 40, or 80, etc. which indicates how much pressure it can hold without bursting. If the pressure (again, total lift which includes vertical lift and pipe friction), is higher then any schedule pvc pipe, the lower portion of the discharge pipe line may need to be galvanized pipe.

SELECT THE SIZE AND TYPE OF PIPE FOR MAXIMUM FLOW RATE AND TOTAL LIFT AS RECOMMENDED BY THE PIPE DEALER.

IRRIGATION SYSTEM

Ms. Brown has indicated that she would prefer a drip irrigation system. Plans are to produce vegetables on the Green Valley farm. There is no question, drip irrigation is the best irrigation method for vegetable production. There are number of different drippers or emitters available on the market for irrigating vegetables, all of them adequate.

Drip irrigation operates on approximately 10 to 15 pounds of pressure per square inch (psi). Where the water will be taken down the hill as on the Green Valley farm, pressure regulators may be required at the lower end of the irrigation system **(every 2.31 feet of fall is equal to 1 pound of pressure)**. Most drippers or emitters compensate for pressure within limits, thus, after determining the elevation drops, pressure regulators may be required as mentioned above. Pressure can also be regulated by installing a globe valve and pressure gauge at each section of drip irrigation turn on station.

A filter system must also be installed near the outlet of the holding pond to filter out the silts in the water. Dripper or emitters are very susceptible to clogging if silt is carried in the water.

IRRIGATION SYSTEM DESIGN

THE CONSULTING IRRIGATION ENGINEER HAS LOCATED SEVERAL IRRIGATION DEALERS IN JAMAICA THAT PROVIDE AN ASSESSMENT AND DESIGN AT NO COST TO THE CLIENT. IT IS RECOMMEND THAT SUCH SERVICES BE REQUESTED FROM A COUPLE OF DEALERS FOR A DRAFT DRIP IRRIGATION SYSTEM DESIGN FOR GREEN VALLEY. THEN, COMPARE DESIGNS WITH RECOMMENDATIONS MADE IN THIS REPORT.

SOME IRRIGATION PRINCIPLES

No matter which irrigation methods and practices are used, it is necessary for the irrigator to understand some basic principles about soils and plants in order to obtain maximum efficiency of the resources and, therefore, optimum production.

SOILS

The soil's most important function is to store water and nutrients for the plants. A soil's texture is the major factor affecting how much water it can hold for plant use. "Available water" refers to the amount of water that a soil can store and is accessible for plant use. Not all the water stored in the soil is available for the plant to use. Available water is the difference between field capacity (the most water the soil can hold in the plant root area) and permanent wilting point (soil water condition reached after the plant is unable to take any more water from the soil - the soil is not completely dry, but the plant is unable to take any more water from the soil.

The following table shows the "available water" for plant use for different soil textures:

SOIL TEXTURE	AVAILABLE WATER (INCHES/FOOT OF SOIL
SANDY	0.5
SANDY LOAM	1.0
LOAM	1.6
CLAY LOAM	2.0
CLAY	1.8

The Green Valley soils are clay loam to clay soils in texture, thus, hold around 2.0 inches of available water for plant use when at field capacity (filled with water).

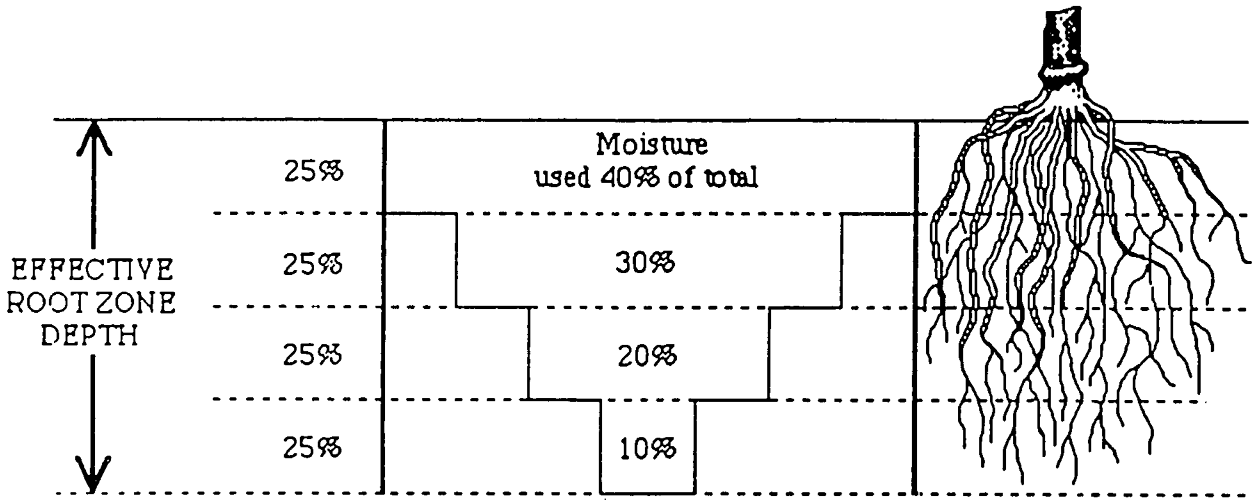
PLANTS

The roots of the plants are in contact with the soil and feed the plants with water and nutrients as available in the soil. Root depths vary by crops. For vegetables, root depths are shown in the following table:

12 to 15 in.	15 to 24 in.	24 to 30 in.	30 to 40 in.
Lettuce	Cabbage	Carrots	Tomatoes
Radishes	Cauliflower	Eggplant	Asparagus
Spinach	Peas	Potatoes	Melons
Onions	Green beans	Cereal crops	Parsnips
Broccoli	Cucumbers	Cantaloupe	Turnips
Brussel Sprouts	Peppers	Groundnut	Pumpkins
Celery	Red Beets		Squash
Garlic	Swiss Chart		Sweet Potatoes
Strawberries			

As indicated above, the Green Valley soils hold about 2.0 inches of water per foot. Using the appropriate vegetable root depths in the above table, an irrigator can determine the available water for each vegetable crop.

About 70% of all the plant roots are located in the top half of the root zone. Accordingly, the plant takes 70% of its water and nutrient needs from its top half of the root zone. The distribution of the plant roots as found in the soil is approximately as shown in the following figure:



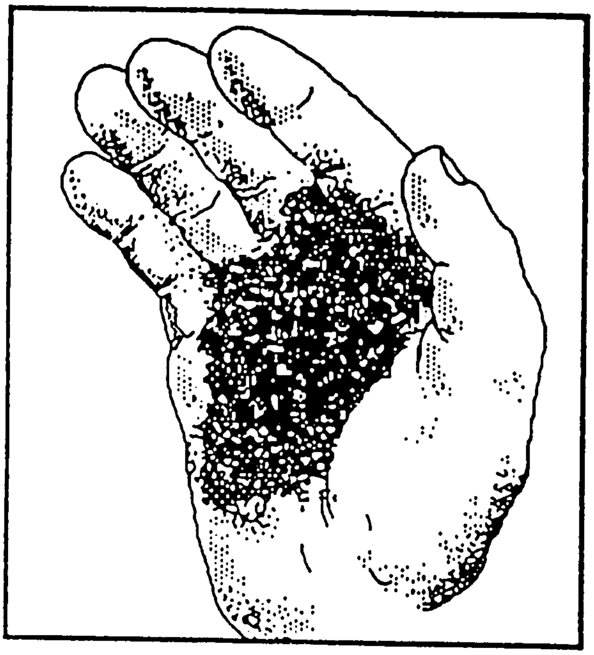
PLANT ROOT DISTRIBUTION IN THE SOIL

In applying irrigation water, the goal is to fill the soil with water in the entire root area and no more. **EVEN THOUGH 70% OF THE WATER IS TAKEN BY THE PLANT FROM THE TOP HALF OF THE EFFECTIVE ROOT AREA, IRRIGATION WATER SHOULD STILL BE APPLIED THROUGHOUT THE ENTIRE PLANT ROOT DEPTH.**

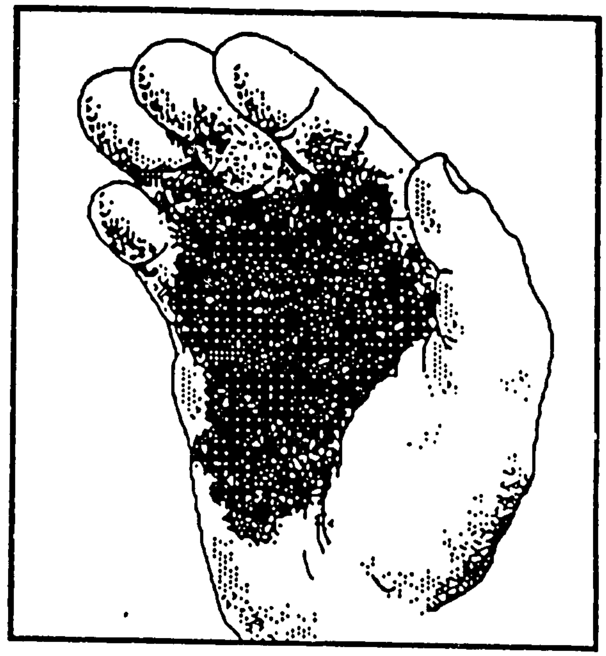
IRRIGATION SHOULD BEGIN WHEN 50% OF THE AVAILABLE WATER HAS BEEN DEPLETED FROM THE SOIL IN THE PLANT ROOT ZONE AREA.

FEEL AND APPEARANCE METHOD FOR DETERMINING AVAILABLE WATER

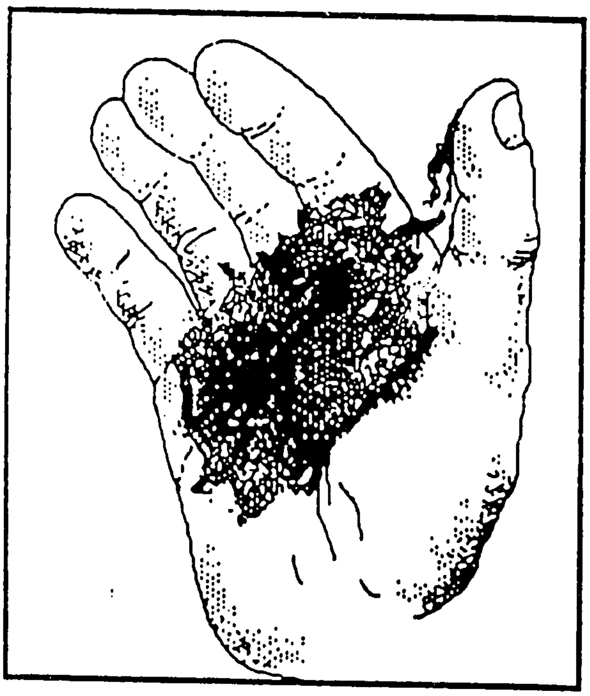
Available water remaining in the soil for plant use can be approximated by feeling and by the appearance of the soil. the irrigator needs to have a soil auger available to "pull' soil samples from different depths of the soil to feel it and determine available water remaining for plant use. Using the feel and appearance method to estimate the available water for a clay loam and clay soil is illustrated in the following page. Also, a more detailed chart for using the feel and appearance method for estimating the available water is attached following the illustration page.



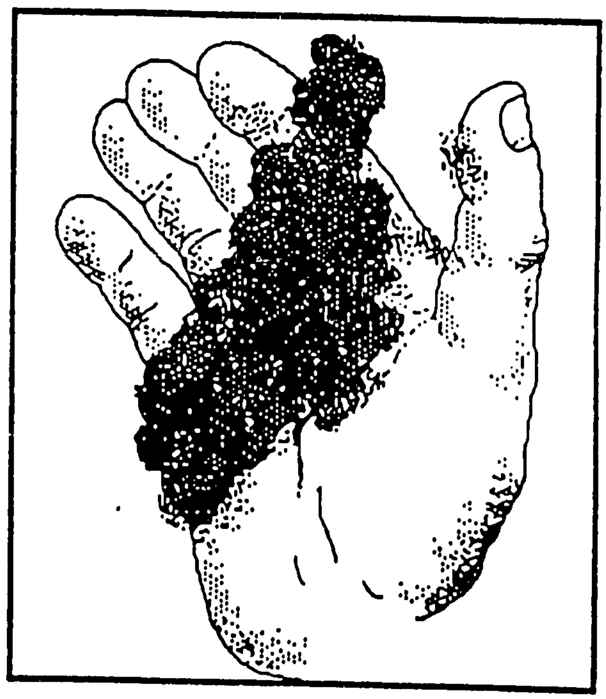
* 0 to 25% Available Moisture - Crumbles readily, "balls" with difficulty and breaks easily.



* 25 to 50% Available Moisture - Does not crumble, easily, forms readily, will "ball" with pressure.



* 50 to 75% Available Moisture - Forms "ball" readily, will "ribbon" out between thumb and forefinger. Somewhat slick feeling.



* 75 to 100% Available Moisture - Easily "ribbons" out. Has slick feeling.

USING THE FEEL AND APPEARANCE METHOD FOR FINE TEXTURED SOILS
CLAY LOAMS AND SILTY CLAY LOAMS
TO ESTIMATE AVAILABLE WATER

FEEL AND APPEARANCE CHART FOR AVAILABLE MOISTURE IN THE ROOT ZONE

Percentage of Soil Moisture Remaining	Soil Texture: [Sands] (Loamy Sandy)	[Sandy Loams] (Fine Sandy Loams)	[Loams and Silt Loams] (Clay Loams)	[Silty Clays] (Clays)
0 to 25%	Dry, loose soil flows through fingers [0 to 0.20] (0 to 0.25)	Dry, loose soil flows through fingers [0 to 0.40] (0 to 0.50)	Powdery, dry, crusty [0 to 0.55] (0 to 0.55)	Hard, cracked [0 to 0.50] (0 to 0.50)
25 to 50%	Appears dry, will not form a ball with pressure. [0.20 to 0.40] (0.25 to 0.50)	Appears dry, forms very weak ball under pressure [0.40 to 0.75] (0.50 to 1.00)	Partly crumbly, forms ball under pressure [0.55 to 1.10] (0.55 to 1.10)	Partly pliable, forms good ball under pressure [0.50 to 0.95] (0.50 to 0.95)
50 to 75%	Appears dry, forms very weak ball under pressure [0.40 to 0.60] (0.50 to 0.75)	Almost dry, tends to form a crumbly ball under pressure [0.75 to 1.10] (1.00 to 1.50)	Forms partly plastic ball, may slick with pressure [1.10 to 1.65] (1.10 to 1.65)	Forms ball and will ribbon [0.95 to 1.45] (0.95 to 1.45)
75 to 100%	Tends to stick, forms weak crumbly ball [0.60 to 0.80] (0.75 to 1.00)	Forms weak ball, will not stick [1.10 to 1.50] (1.50 to 2.00)	Forms very pliable ball and may stick [1.65 to 2.20] (1.65 to 2.20)	Easily ribbons and has slick feeling [1.45 to 1.90] (1.45 to 1.90)
100%	The soil is at field capacity. Upon squeezing, no free water appears on the soil, but a wet outline of the ball is left in the hand.			

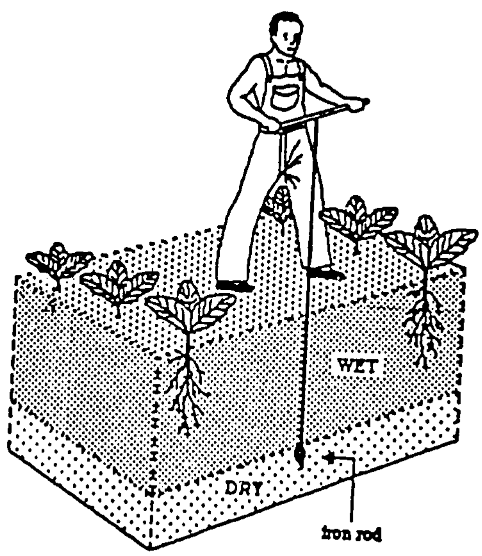
NOTE: Figures in each parentheses show inches of water available moisture remaining per foot of depth.

Take soil samples throughout the top half of the root zone in various areas in the field. For a clay loam to clay soils, when squeezing and feeling the soil samples, the soil doesn't crumble easily but forms a "ball" with pressure when squeezed in the palm of the hand, about 50% of the available water has been depleted from the plant root zone area. Then irrigation should begin.

IRRIGATION SHOULD BE STOPPED WHEN IRRIGATION WATER HAS REACHED NEARLY THE ROOT DEPTH OF A THE VEGETABLE CROP (DEPTH OF ROOTS AS INDICATED IN THE ABOVE TABLE).

A way to determine how deep the irrigation water has gone in the soil, an irrigator can use an iron rod. The iron rod is 3/8 inch in diameter and 3 feet in length with an enlarged tip or end. In wet soil, the rod will push into the soil very easily. When the tip or end of the rod reaches dry soil, it will push harder when continuing to push it. the point at which the rod begins to push harder is the line between the wet and dry soil.

Using the iron rod is shown in the following figure:



USING THE IRON ROD

There are limitations where the iron rod can be used. In gravelly or very course soils, where there are rocks present in the soil profile, it may not be possible to push the iron rod into the soil. The soil auger, used for taking soil samples as discussed above, may need to be used in such soils. Even the soil auger may be difficult to use in the gravelly, coarse soils. But it doesn't appear the soils on the Green Valley farms will be any problem for using the iron rod.

The iron rod is not commercially available. It can easily be made in a welding shop using 3/8 inch rod and welding a "T" on one end for a handle and a 1/2 inch ball bearing on the other end as the enlarged tip or end.

SOIL MOISTURE INSTRUMENTS

Technology is available today where instruments such as tensiometer and gypsum blocks can be installed in the soil which indicate when irrigations should begin. **HOWEVER, THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THE FEEL AND APPEARANCE METHOD ALWAYS BE USED TO ESTIMATE AVAILABLE WATER EVEN WHERE SOIL MOISTURE INSTRUMENTS ARE USED. USING THE FEEL AND APPEARANCE METHOD, THE IRRIGATOR WILL BE REQUIRED TO WALK THE FIELDS RESULTING IN BECOMING VISUALLY BETTER ACQUAINTED WITH THE CROP AND SOIL CONDITIONS. THIS IS MOST IMPORTANT IN IRRIGATION MANAGEMENT ON A FARM.**

RAINFALL

Mean rainfall in Jamaica and at the Green Valley farm will exceed the water needs of the plants grown on the farm. However, not all the rainfall is effective or comes at the right time. Rainfall intensities at times are such that the soils are unable to absorb all the rainfall, causing runoff. **THE CONSULTING IRRIGATION ENGINEER RECOMMENDS INSTALLING A RAIN GAUGE ON THE FARM. EVEN THOUGH THE RAIN GAUGE WILL NOT MEASURE THE WATER THAT ACTUALLY ENTERS THE SOIL, RAINFALL DATA FOR THE FARM CAN STILL BE VALUABLE MANAGEMENT INFORMATION.**

After a rain, the iron rod, as discussed above can be used to determine how deep the rain water has penetrated the soil.

Regardless, feeling the soil and noting it appearance periodically will still be necessary to determine when irrigation should take place.

SUMMARY RECOMMENDATION

* **CONSULT VEGETABLE SPECIALIST TO DETERMINE WHETHER CLAY LOAM TO CLAY SOILS HAVE LIMITATION TO WHAT KINDS OF VEGETABLES CAN BE PRODUCED UNDER IRRIGATION.**

* **ACQUIRE AVAILABLE STREAM FLOW WATER INFORMATION.**

* **ACQUIRE ELEVATIONS FOR THE FARM TO DETERMINE DISTANCE WATER HAS TO BE LIFTED.**

* **DETERMINE DISTANCE WATER IS TO BE PUMPED FROM THE STREAM TO THE HOLDING POND(S).**

* OBTAIN DRAFT IRRIGATION SYSTEM DESIGN TO INCLUDE:

    * CENTRIFUGAL IRRIGATION PUMPING PLANT, DRIVEN BY A DIESEL ENGINE WITH A PRIMING DEVICE, CHECK VALVE, PRESSURE GAUGE AND PIPELINE WATER FLOW METER.

    * WATER PIPELINE FROM STREAM TO HOLDING POND.

    * DRIP IRRIGATION SYSTEM WITH TYPES AND NUMBER OF DRIPPERS/EMITTERS, FILTERING SYSTEM, PRESSURE REGULATORS AND PRESSURE GAUGES.

    * COST OF ALL EQUIPMENT COMPONENTS, DELIVERED TO THE FARM AND NOT INSTALLED VS. INSTALLED VS. SUPERVISED INSTALLATION OF THE IRRIGATION SYSTEM.

    * EVALUATE PROPOSED DESIGN(S) WITH RECOMMENDATIONS IN THIS REPORT.

IN ADDITION

* INSTALL RAIN GAUGE(S) ON THE FARM AREA.

* PROVIDE THE IRRIGATOR A SOIL AUGER.

* PROVIDE THE IRRIGATOR AN IRON ROD

* DEALER PROVIDE THE CLIENT THE PUMP PERFORMANCE CURVE.

MISTFLORA LTD.

10 TRAFALGAR ROAD

ST. THOMAS

KINGSTON 5, JAMAICA

IRRIGATION REPORT

APRIL 11, 1995

DONALD J. BROSZ
CONSULTING IRRIGATION ENGINEER

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT

CHEMONICS INTERNATIONAL CONSULTING DIVISION
WASHINGTON, D.C.

~106

MISTFLORA LTD.

10 TRAFALGAR ROAD

ST. THOMAS

KINGSTON 5, JAMAICA

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT IRRIGATION SCOPE OF WORK

* Consulting Irrigation Engineer will spend one day on the farm to make a preliminary assessment of the irrigation needs of the Client's farm.

* Consulting Irrigation Engineer to provide the Client with a report outlining the results of the work and make recommendations to the Client with respect to irrigation

MISTFLORA LTD. FARM IRRIGATION RECOMMENDATIONS

FARM IRRIGATION SYSTEM OPERATIONS, MANAGEMENT AND MAINTENANCE

* If existing irrigation pumping plant is used to operate the drip irrigation system, a booster pump needs to be installed to provide water and pressure the highest area in the shade houses not reached now.

* Thought should be given to installing a new irrigation pumping plant with a holding tank to operate the drip irrigation system by gravity pressure.

* Use a 20 minute drip irrigation time, irrigating twice a week, as an irrigation schedule guide. To more accurately schedule irrigations, use the soil feel and appearance method.

* Apply 0.5 inches of water per irrigation to a soil depth of 6 inches.

* To determine holding pond capacity: 1 cubic foot or capacity equals 7.5 gallons.

* To determine gravity pressure: 2.31 feet of elevation difference or fall (slope) equals 1 pound per square inch of pressure (psi).

IRRIGATION MANAGEMENT REPORT

MISTFLORA LTD.

KINGSTON, JAMAICA

APRIL 11, 1995

INTRODUCTION

Mistflora Ltd. began production and export of cut flowers in 1978, and switched into the production and export of fresh culinary herbs. Mistflora operates on 7 1/2 acres of land, 2 acres under green house, in the Red hills area on the outskirts of Kingston. Production includes basil, chives, tarragon, sage and oregano.

The Mistflora farm is using drip irrigation on the 2 acres of herbs. Ms. Dawn Ottey, General Farm Manager, expressed an interest in expanding the operations to producing vegetables on the remaining undeveloped 5 1/2 acres.

MISTFLORA IRRIGATION SYSTEM

The Mistflora farm water resources is a surface water holding pond. The water in the holding pond comes from the green houses. The green houses are covered with plastic, so no rain water falls on the herb plants. The water is diverted off the plastic green houses to channels leading to the holding pond. The rain waters diverted off the green houses is essentially the total water supply. A small quantity of water is available from a holding tank at the living quarters where the water source is the runoff from the roof of the home.

From the holding pond, the water is pumped by an electric driven irrigation pumping plant, through a filtering system, directly into the drip irrigation lines. The irrigation pumping plant does not have the capacity to pump water to a small area, which is the highest point in the green house.

The land area in the green house is relatively steep. The pressure to the drip lines is controlled by automatic pressure regulators. Mrs. Ottey and her irrigation supervisor, Junior, indicated the pressure relief valves are giving some problems, not regulating the pressure as the valves should.

SOME OBSERVATIONS AND RECOMMENDATIONS

HOLDING POND

Mrs. Ottey and irrigation supervisor, Junior, are not sure how much water can be stored in the holding pond. The consulting Irrigation

Engineer did not have the time to measure the pond. For the workers at Mistflora farm to determine the quantity of water in the holding pond, the following procedure can be used:

1 CUBIC FOOT OF CAPACITY IS EQUAL TO 7.5 GALLON.

For example, if a holding pond is 50 feet in length, 30 feet in width and 10 feet in depth, the capacity is 15,000 cubic feet (50 x 30 x 10 = 15,000) or a capacity of 112,500 gallons of water (15,000 x 7.5 = 112,500). Thus, measure the pond width, length and depth in feet. Multiply the lengths together and one gets cubic feet of capacity of the holding pond. Multiply the cubic feet by 7.5 and one gets the holding capacity of the pond in gallons of water. Easy - Right!!

IRRIGATION PUMPING PLANT

As indicated above, the irrigation pumping plant capacity is such that it is unable to pump water to a small area in the shade house - the highest point in the green house.

THE CONSULTING IRRIGATION ENGINEER RECOMMENDS A SMALL BOOSTER PUMP BE INSTALLED NEAR THE FILTER. OPERATE THE BOOSTER PUMP ONLY DURING THE TIMES THE AREA THAT CAN NOT BE IRRIGATED NOW IS TO BE IRRIGATED. Consult one of the irrigation dealers and suppliers in Jamaica to make the necessary field measurements for determining how much "boost" is needed and purchase a pump accordingly.

OR, THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THAT THOUGHT SHOULD BE GIVEN TO PUMPING WATER FROM THE HOLDING POND DIRECTLY INTO A 5,000 TO 10,000 GALLON HOLDING TANK. PLACE THE HOLDING TANK SOME 5 FEET ABOVE THE HIGHEST POINT IN THE GREEN HOUSE (AREA NOW NOT ABLE TO BE IRRIGATED) AND IRRIGATE THE GREEN HOUSE AND PROPOSED EXPANSION AREA BY GRAVITY PRESSURE. REPLACE THE PRESENT PUMP WITH ONE HAVING ENOUGH CAPACITY TO DELIVER THE WATER TO THE HOLDING TANK. Again, consult one of the irrigation dealers in Jamaica to have them make the necessary field measurements for determining the capacity of the irrigation pumping plant.

The consulting Irrigation Engineer has a couple of reasons for considering the latter recommendation. One - when the electrical power goes off, as it seems to happen often, water stored in the holding tank will make it possible to continue operation of the drip irrigation system while the irrigation pumping plant is no operating. Two - there is sufficient land slope in the green house area and in the proposed expansion area to operate the drip system by gravity pressure. Having water storage in the holding tank and sufficient gravity pressure gives the option to operate the drip system without the irrigation pumping plant. Oh yes, another reason - the drip pressure will be easier to regulate with the holding tank pressure then with pressure from the pump.

If the latter option is selected, purchase a new irrigation pumping plant, large enough to pump the water to the holding tank. Pump the water through the existing filter system leaving it at its present location. Purchase a large enough irrigation pumping plant so the booster pump is not needed as discussed with the first recommendation, above.

GRAVITY PRESSURE

As indicated above, the slope of the land area in the green houses is sufficient to operate the drip irrigation system by gravity pressure.

EVERY 2.31 FEET OF DROP IN ELEVATION (SLOPE) IS EQUAL TO 1 POUND PER SQUARE INCH (psi) OF PRESSURE.

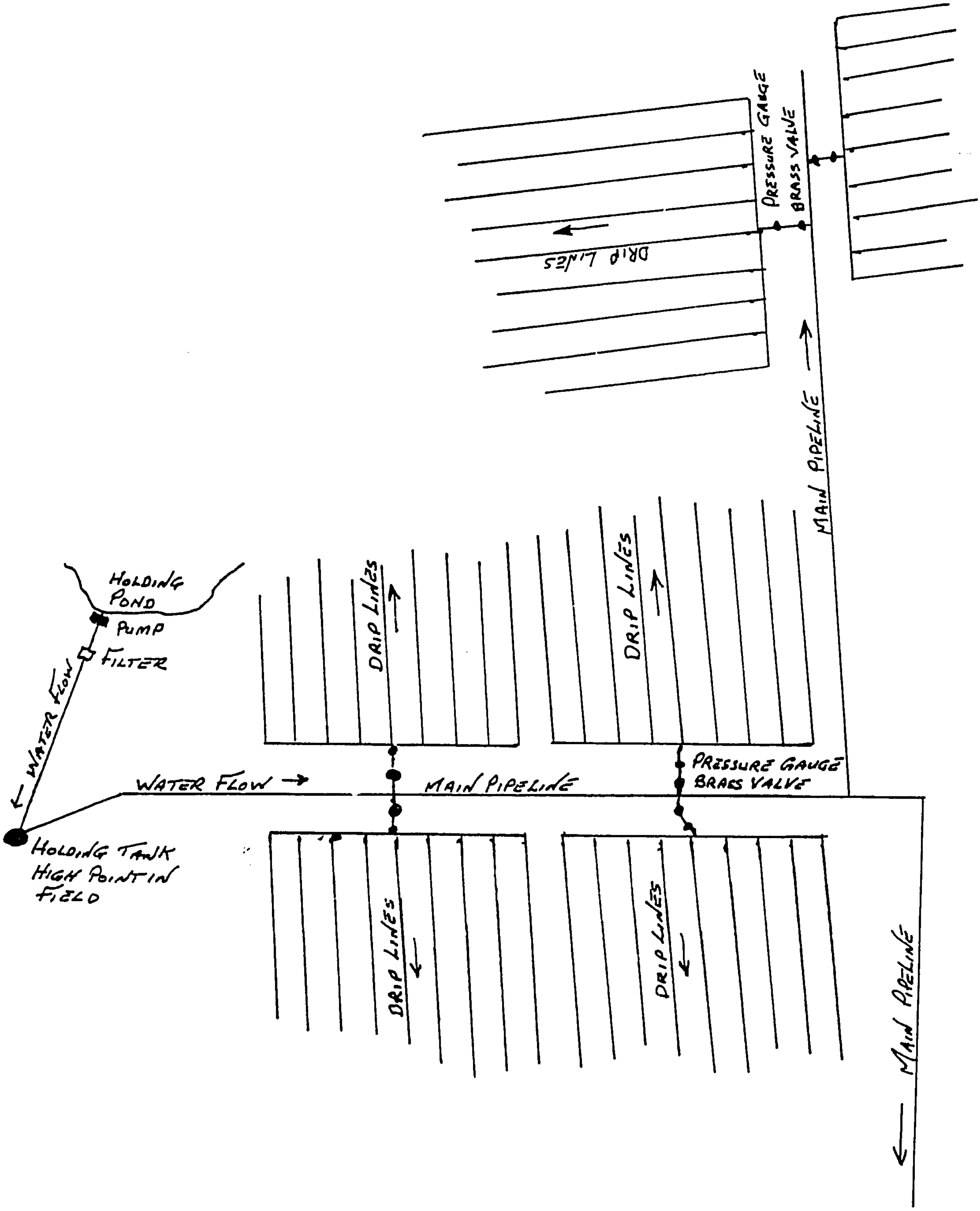
A drip irrigation system should operate at 10 to 15 psi. Thus, the recommendation to place the holding tank at about 5 or so feet above the highest point in the green house area (in the area that can not be irrigated now) because that results in a beginning pressure of 11.6 psi (2.31 x 5 = 11.6). The highest area can now be irrigated and there is sufficient slope in the green house area to continue with plenty of pressure to operate the drip irrigation system.

DRIP IRRIGATION SYSTEM REORGANIZATION

THE CONSULTING IRRIGATION ENGINEER RECOMMENDS TAKING THE EXISTING 1 1/2 INCH PVC MAINLINE PIPE AND RELOCATE IT IN THE PRESENT WALKWAY AREA FOR THE ENTIRE LENGTH OF THE GREEN HOUSE AND BRANCH OFF WHERE REQUIRED. THIS SAME MAINLINE CAN ALSO BE THEN EXTENDED INTO THE PROPOSED EXPANSION AREA WHEN APPROPRIATE. THE MAINLINE MAY BE PLACED UNDERGROUND, OUT OF THE WAY, FOR EASE OF TRAVEL ON THE WALKWAY. This recommendation is made for either option - keeping the existing irrigation pumping plant and installing a booster pump, or, if a new irrigation pumping plant is installed along with a holding tank.

Off the mainline, both left and right, install drip line stations using brass globe valves and pressure gauges to regulate the pressure. A sub-mainline using 3/4 inch pvc be installed with 6 to 8 drip lines coming off each station. Leave the drip lines as they now are installed tapping them into the 3/4 inch sub-mainline. The line drawing on the following page illustrates the proposed installation.

THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THE USE OF BRASS GLOBE VALVES AND PRESSURE GAUGES FOR CONTROLLING THE DRIP LINE PRESSURES. LESS PROBLEMS DEVELOP WITH THE HAND CONTROL VALVES THEN WITH AUTOMATIC CONTROL VALVES. Drippers or emitters are built to regulate their pressure in the drip line but pressure needs to be



DRIP IRRIGATION SYSTEM ILLUSTRATION

regulated to the drip line, delivering about 10 to 15 psi to the drip lines.

IRRIGATION AMOUNTS

The green houses are covered with plastic so no rain water is used to supply water to the herbs. All the rainfall runs off and diverted into the holding pond, as indicated earlier in this report. All water requirement by the herbs must be applied by irrigation. The green house land area is about 2 acres in size. It is estimated by the consulting Irrigation Engineer, that about a fourth of the land area (0.5 acre, total) is actually irrigated (minus walkways, irrigation water is placed right by the plants, etc.).

For close growing plants such as the herbs, the drippers are spaced 1 foot apart on the lines. Each dripper or emitter too, is designed to discharge about 1 to 1.5 gallons/hour (gph). As indicated above, leave the drip lines as they are now laid out - one line between 2 rows of plants and two lines between 3 rows of plants. Again, time did not permit the consulting Irrigation Engineer to determine the number of drip lines and number of drippers or emitters are in use presently in the herb shade houses. If the assumption is right that about 0.5 acres are actually irrigated, there are about 21,000 drippers in use in the green houses

IT IS ASSUMED BY THE CONSULTING IRRIGATION ENGINEER THAT THE HERBS WILL REQUIRE AT LEAST 1 INCH OF WATER PER WEEK (A HERB SPECIALIST SHOULD BE CONSULTED TO ENQUIRE HOW MUCH WATER IS REQUIRED BY HERBS FOR MAXIMUM PRODUCTION).

The soils on the Mistflora farm are a loam soil and hold 1.5 inches of water per foot of soil. Herbs effective root depths are about 6 to 8 inches. Thus, when the loam soil is properly irrigated, about 0.75 inches of water is available to the herbs in the 6 inches of soil (**1.5 x 0.5 feet or 6 inches = 0.75**). Irrigations should begin when about one half (50%) of the 0.75 inches is depleted from the herbs root zone area (**0.75 x 0.5 = 0.4**) or 0.4 inches. For irrigating herbs, when 0.5 inches is depleted would be a good irrigation schedule.

WHEN EACH DRIPPER FLOWS 1 GPH, TO APPLY 0.5 INCHES OF WATER/IRRIGATION THE DRIP LINES NEED TO BE TURNED ON FOR A PERIOD OF ABOUT 20 MINUTES. AGAIN, IF HERBS USE 1 INCHES/WEEK, EACH DRIP LINE NEEDS TO BE OPERATED TWICE PER WEEK. IRRIGATING FOR 20 MINUTES, TWICE A WEEK WILL BE THE MOST EFFICIENT WAY TO IRRIGATE THE HERBS.

If the drippers are designed to flow 1 gallon/hour (contact irrigation dealer the verify the designed flow for each dripper), the pipe sizes are such that 1200 to 1400 drippers can be operated at the same time.

DETERMINING WHEN TO IRRIGATES

How does one determine when 50% of the water is depleted from the root zone area? Take a small garden shovel, dig up some soil at the 6 inch level and if it is crumbly as one feels it with the hand, it is time to irrigate.

DETERMINING WHEN TO STOP IRRIGATIONS

How does one determine when enough irrigation water has been applied? Again, with a small garden shovel, dig down 6 inches and see if the irrigation water has soaked down to the 6 inch level while the drippers are operating (after about 20 minutes). If the water has not reached the 6 inch level in the 20 minutes, the drip lines should be operated for an additional time until water does reach the 6 inch level. Or, if the water reaches the 6 inch level sooner, the drip lines can be turned off.

IRRIGATION SCHEDULING

The irrigation time may vary with the type of herb plants, stage of plant growth, time of season, etc. The above suggested schedule is to serve as a guide. Thus, continually feel and observe the soil to determine irrigation beginnings and when irrigations can be turned off.

SPRINKLER VS DRIP IRRIGATION

It was observed that the plants seemed to be taller and more lush in the experimental sprinkler irrigated area of the green house in comparison to the drip irrigated area. The sprinklers are applying much more water then the drip irrigation per period of time they are operated. Thus, more water is being applied in the sprinkler area then in the drip area per irrigation.

TROPICROP MUSHROOMS LTD.

5 TANGERINE PLACE

ST. THOMAS

KINGSTON 10, JAMAICA

IRRIGATION REPORT

APRIL 12, 1995

DONALD J. BROSZ
CONSULTING IRRIGATION ENGINEER

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT

CHEMONICS INTERNATIONAL CONSULTING DIVISION
WASHINGTON, D.C.

115

TROPICROP MUSHROOM LTD.

5 TANGERINE PLACE

ST. THOMAS

KINGSTON 10, JAMAICA

SMALL BUSINESS EXPORT DEVELOPMENT PROJECT IRRIGATION SCOPE OF WORK

* Consulting Irrigation Engineer to spent one day on the farm making a preliminary assessment of the irrigation need of the Client's farm.

* Consulting Irrigation Engineer t provided the Client with a report outlining the results of the work and make recommendations to the Client with respect to irrigation.

TROPICROP MUSHROOM LTD. FARM IRRIGATION RECOMMENDATIONS

FARM IRRIGATION SYSTEM OPERATION, MANAGEMENT AND MAINTENANCE

* The sprinkler irrigation system be replaced with a drip irrigation system on the upper farm, Calla Lilies field.

* The drip irrigation system be designed by an in country irrigation dealer including equipment and supplies according to recommendations made in this report.

* Irrigate the Calla Lilies about twice a week, applying 0.5 inches of irrigation water/irrigation to a soil depth of 6 inches.

* Irrigate the coffee plants to a soil depth of 10 or so inches.

* Use the soil feel and observation to determine when to begin irrigations and when to turn off the irrigation for both the Calla Lilies and the coffee plants.

* The sprinkler irrigation system be replaced with a drip irrigation system on the lower farm coffee field.

* 2.31 feet of fall or drop in elevation (slope) is equal to 1 pound of pressure per square inch (psi).

* One cubic foot of capacity (holding pond) is equal to 7.5 gallons

IRRIGATION MANAGEMENT REPORT

TROPICROP MUSHROOMS LTD.

ST. THOMAS

KINGSTON, JAMAICA

APRIL 12, 1995

INTRODUCTION

The Tropicrop Mushroom farm land areas are located high in the Blue Mountains. The General Farm Manager is Mrs. Jennifer Lyn. The farm never was used for mushroom production.

On the upper farm in the Blue Mountains, the farm production includes 1 to 2 acres of Kiwi Calla Lilies using sprinkler irrigation. Mrs. Lyn indicated she is wanting to change from sprinkler irrigation to drip because of a limited water supply. Also, she is interested in expanding the Calla Lilies production area. This farm also produces coffee, but no irrigation is used for the coffee production.

On the lower farm, also in the Blue Mountains, Tropicrop Mushroom farm is producing coffee, using sprinkler irrigation. Again, Mrs. Lyn indicated she would like to change the irrigation system to drip irrigation.

OBSERVATIONS AND RECOMMENDATIONS

On the Calla Lilies field, the water source is stream water delivered through a pipeline serving several users. Mrs. Lyn indicated that at times the water supply is very limited, not sufficient to operate the sprinkler system during the low water flow times.

THE CONSULTING IRRIGATION ENGINEER CONCURS WITH MRS. LYN AND RECOMMENDS THAT THE EXISTING SPRINKLER SYSTEM ON THE CALLA LILIES FIELD BE REPLACED WITH A DRIP IRRIGATION SYSTEM.

The slope of the land is such that the drip irrigation system can be operated by gravity pressure. **FOR EACH 2.31 FEET OF FALL OR DROP IN ELEVATION (SLOPE) EQUALS 1 POUND PER SQUARE INCH (PSI) OF PRESSURE.** A drip irrigation system is operated with a pressure of 10 to 15 psi.

The drip irrigation system should include a holding tank of about 40,000 gallons, located about 5 feet above in elevation of the upper end (high end) of Calla Lilies field. A filter system should be installed in the present delivery pipeline, ahead of the holding tank. A 1 1/2 inch pvc mainline can be installed near the center of the field, down the slope. One drip line will be sufficient to be installed in each row of the Calla Lilies. Each drip line should be fitted with a brass globe valve and pressure gauge at the head of the drip line as it comes off the mainline, to regulate the pressure at 10 to 15 psi. An example line drawing illustration is shown in the following page.

Of the approximately 2 acres of Calla Lilies, approximately about a fourth of the area or 0.5 acres is actually irrigated using drip irrigation. Using sprinkler irrigation, the total 2 acres is irrigated. Thus, using drip irrigation in this situation will require much less water.

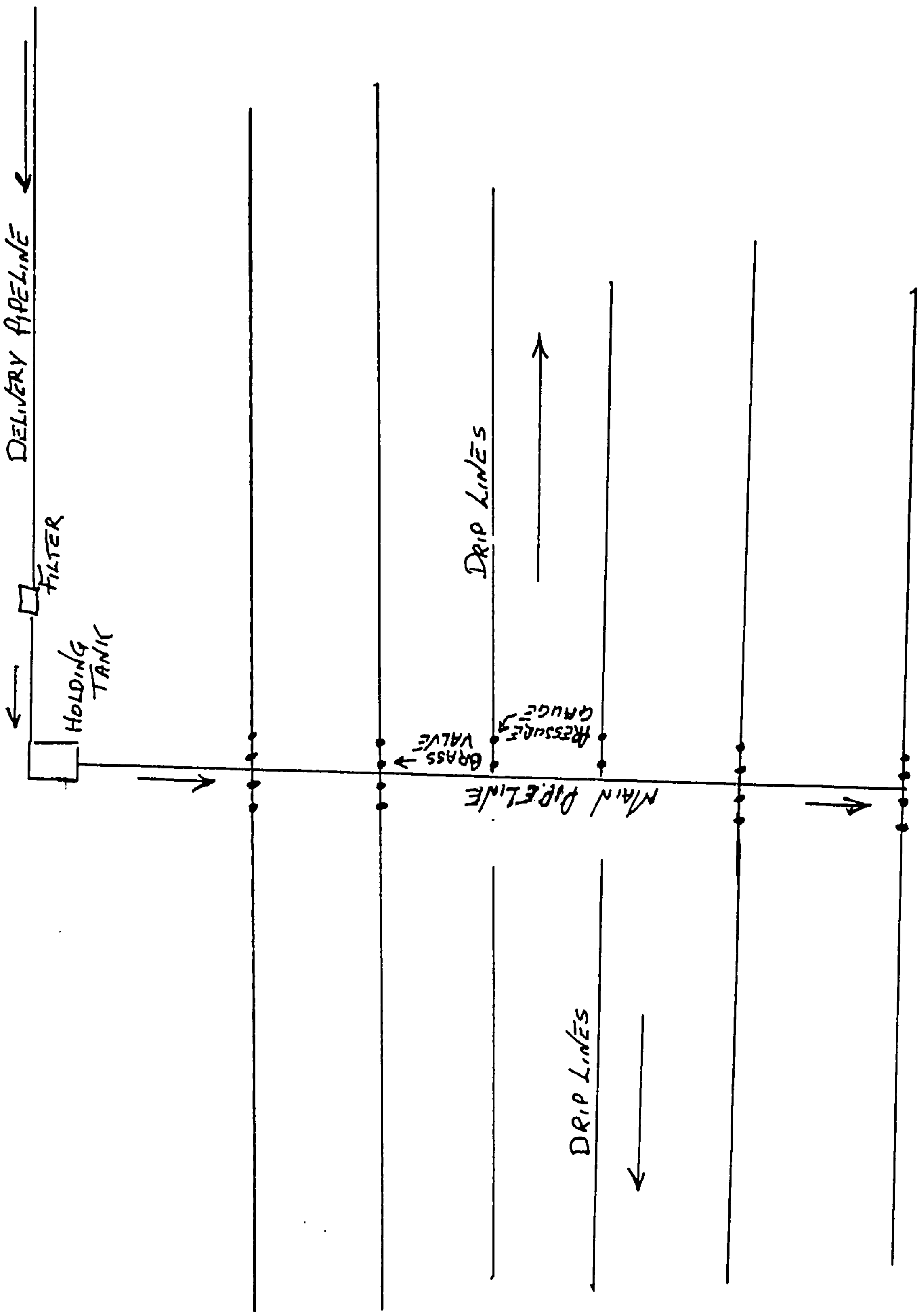
THE CONSULTING IRRIGATION ENGINEER ASSUMES THAT ABOUT 1 INCH OF WATER APPLIED EACH WEEK BY IRRIGATION DURING LOW RAINFALL TIMES WILL BE SUFFICIENT TO MEET THE NEEDS OF THE CALLA LILIES. Mrs. Lyn, you may want to consult a Calla specialist to confirm this assumption.

The concern of very low flows during drought time may possibly be solved with drip irrigation. **A FLOW AS SMALL AS 5 GALLONS/MINUTE (GPM), IS SUFFICIENT TO APPLY 1 INCH OF WATER PER WEEK ON 8 ACRES OF CALLA LILIES WITH PLANT ROWS AS PRESENTLY SPACED. TOTAL ACTUAL ACRES IRRIGATED WOULD BE 2 ACRES. THE DRIP IRRIGATION SYSTEM WOULD NEED TO BE OPERATED 24 HOURS PER DAY TO DO THE ABOVE.**

Drippers are generally designed to flow 1 to 1.5 gallons/hour (gph). Thus, small water supplies can sufficiently irrigate a relatively large area. Discussions with Mrs. Lyn included locating another water supply for use during drought times. **THE CONSULTING IRRIGATION ENGINEER RECOMMENDS THAT NO ADDITIONAL WATER SUPPLY TO SUPPLEMENT THE EXISTING WATER SOURCE BE DEVELOPED UNTIL IT BECOMES EVIDENT THAT THE PRESENT WATER SOURCE IS NOT SUFFICIENT. AS INDICATED ABOVE, A SMALL FLOW AS LITTLE AS 5 GPM MAY BE SUFFICIENT TO IRRIGATE THE PRESENT ACREAGE OF CALLA LILIES PLUS AN INCREASE IN ACREAGE.**

IRRIGATION AMOUNTS

The soils on the Calla Lilies farm is a loam in texture which holds 1.5 inches of water per foot of soil. The Lilies have an effective root zone depth of about 6 to 8 inches. Thus, when the loam soil is properly irrigated, about 0.75 inches of water is available to the Lilies in the 6 inches of soil **(1.5 x 0.5 of 6 inches = 0.75)**. Irrigations should begin when about one half (50%) of the 0.75 inches is depleted from the Lilies root zone area **(0.75 x 0.5 = 0.4)** or 0.4 inches. For irrigating the Calla Lilies, when 0.5 inches is depleted would be a good irrigation schedule.



DRIP IRRIGATION SYSTEM ILLUSTRATION

WITH EACH DRIPPER FLOWING 1 GPH, TO APPLY 0.5 INCHES OF WATER/IRRIGATION, THE DRIP LINES NEED TO BE TURNED ON FOR A PERIOD OF ABOUT 20 MINUTES. AGAIN, ASSUMING LILIES USE 1 INCHES/WEEK, EACH DRIP LINE NEEDS TO BE OPERATED TWICE PER WEEK. IRRIGATING FOR ABOUT 20 MINUTES, TWICE A WEEK WILL BE THE MOST EFFICIENT WAY TO IRRIGATE THE LILIES.

If the drippers are designed to flow 1 gph, the pipe sizes are such that 1200 to 1400 drippers can be operated at the same time.

DETERMINING WHEN TO IRRIGATE

How does one determine when 50% of the water is depleted from the root zone area? Take a small garden shovel, dig up some soil at the 6 inch level and if it is crumbly as one feels it with the hand. it is time to irrigate.

DETERMINING WHEN TO STOP IRRIGATIONS

How does one determine when enough irrigation water has been applied? Again, with a small garden shovel, dig down 6 inches and see if the irrigation water has soaked down to the 6 inch level while the drippers are operating (after 20 minutes). If the water has not reached the 6 inch level in the 20 minutes, the drip lines should be operated for an additional time until water does reach the 6 inch level. Or, if the reaches the 6 inch level sooner, the drip lines can be turned off.

IRRIGATION SCHEDULING

The irrigation time may vary with the stage of plant growth, time of season, rainfall, etc. The above suggested schedule is to serve as a guide. Thus, continually feel and observe the soil to determine irrigation beginnings and when irrigations can be turned off.

HOLDING POND

If it is necessary to locate and store and additional supply of irrigation water for the Calla Lilies, to calculate capacity of a holding pond can be done by using the following:

ONE CUBIC FOOT OF CAPACITY IS EQUAL TO 7.5 GALLONS

For example, if a holding pond measures 30 feet in length, 20 feet in width and 10 feet in depth, the capacity would be 45,000 gallons **(30 x 20 x 10 = 6000 x 7.5 = 45,000).**

Mrs. Lyn and the consulting Irrigation Engineer discussed possibly storing as much as 326,000 gallons of water. After giving this more analysis by the consulting Irrigation Engineer, per discussions above relating to water needed, storage in the 40,000 to 60,000 gallons would be sufficient.

OBSERVATIONS AND RECOMMENDATIONS

On the lower farm in the Blue Mountains, coffee is produce and irrigated using sprinkler irrigation.

AGAIN, THE CONSULTING IRRIGATION ENGINEER CONCURS WITH MRS. LYN AND RECOMMENDS THAT THE SPRINKLER IRRIGATION SYSTEM BE REPLACED USING DRIP IRRIGATION.

Use a similar layout as on the Calla Lilies with a holding tank, filter system, mainline and regulate pressure drip line pressures using brass globe valves and pressure gauges. Place the drippers by each coffee plant.

IRRIGATION SCHEDULING

Coffee plant root depths will be deeper than Calla Lilies. Apply irrigation water to a depth of about 10 inches or so for each irrigation. Again, use a small garden shovel to dig down to the 10 inch level and observe when water reaches this depth before turning off the drippers. Also, begin irrigations when the soil becomes crumbly when feeling it.

NON-FARM VISITS MADE BY THE CONSULTING IRRIGATION ENGINEER

IRRIGATION DEALERS AND SUPPLIERS

The consulting Irrigation Engineer visited with the following Jamaican irrigation dealers and suppliers:

* Caribbean Industrial Equipment Ltd. - Mr. Lance Powell, Owner, located in Kingston - personally visited the place of business.
* Jamaica Drip Irrigation - Mr. Shelom Hodala, Owner, located in Mandeville - visit by telephone conversation.
* Ladimar Irrigation - Mr. Leonard Ramdial, Owner, located in Kingston - visited by telephone conversation.
* Pumps and Irrigation, Ltd. - Mr. Lucius White, Owner, located in Kingston - visited by telephone.

Very similar information was given by all the irrigation dealers and suppliers during the visits by the consulting Irrigation Engineer. All of the irrigation companies provide the following services:

* Stock new sprinkler and drip irrigation equipment and supplies and irrigation pumping plants.
* New system costs vary from farm to farm. Drip irrigation costs vary from $800 to $1200 U.S. per acre where fruit trees are irrigated and $1200 to $1600 U.S. per acre where vegetables are irrigated. This cost includes all equipment along with the irrigation pumping plant but does not included installation costs.
* Stock replacement equipment and supplies for sprinkler and drip irrigation systems and for irrigation pumping plants - have facilities to do repairs such as on pumps, etc.
* Provide draft design and cost estimates to the farmer at no cost.
* Provide irrigation system installation services or supervisory services where farm labor installs the system. Cost for both dealer installations or the supervisory services is $125 to $150 U.S. per day.
* Work with all farm sizes from the very small to the very large estates.

* Payment for equipment is negotiable - certain amount down and remaining after equipment has been installed and operating satisfactorily.

CONSULTING FIRMS

Hydrology Consulting Ltd.

The consulting Irrigation Engineer visited with Mr. Michael White, Managing Director/Hydrogeologist, Hydrology Consulting, Ltd., Kingston at his office. Mr. White and his associates provide water resource consulting services - groundwater locations and quantities and qualities, surface water quantities and qualities, supervise well drilling, design pumping plants, etc. The firm works very little with the small farmer, mostly with large farm estates.

Wallace Evans Jamaican Ltd.

The consulting Irrigation Engineer also visited with Mr. Peter Hughes, Engineer, Wallace Evans Jamaican Ltd., Kingston by telephone. The firm provides irrigation design services but very seldom works with small farms. Most of the firms work is with large farm estates.

GOVERNMENT AGENCIES

Underground Water Authority

The consulting Irrigation Engineer visited with Mr. Basil Fernandez, Director, Underground Water Authority, Kingston by telephone. The Jamaican Underground Water Authority collects both underground and surface water data relating to location, quantity, quality, etc. The information is available to the public at a nominal cost.

National Irrigation Commission

The consulting Irrigation Engineer visited with Mr. Milton Henry, Associate Director, National Irrigation Commission, Kingston by telephone. The National Irrigation Commission (NIC) is a Jamaican Government entity that works with developing irrigation schemes or irrigation districts. The NIC delivers and sells water to a group of farmers organized into an irrigation district through a central irrigation delivery system. The NIC builds the stream or river diversion structure and main canal or pipeline and delivers the water. The farmers develop their own irrigation systems and pick up the water at beginning of their field(s). Mr. Henry expressed an interest in the SBED Project wanting to visit with Mr. Steve Wade about the potential for developing export cropping programs on the NIC irrigation districts. NIC does not work with individual farm irrigation development.

University of West Indies

The consulting Irrigation Engineer visit with Dr. Joseph Lindsay, Professor and Ms. Selena Topper, Continuing Education Coordinator. A personal visit was made to both Dr. Lindsay's and Ms. Topper's offices to discuss with them about the upcoming irrigation short course to be conducted by the University of West Indies. The irrigation short course entitled "Irrigation: Principles and Practices for Caribbean Agriculture" is scheduled to be held on May 29 to June 9, 1995. A similar irrigation short course was conducted in 1992. Both Dr. Lindsay and Ms. Topper indicated the feedback from the students attending the 1992 short course told them that the short course was much too technical. The short course was designed and oriented for farm irrigation supervisors. As the short course faculty found, most farm irrigation supervisors have only a high school diploma. Farmers told the consulting Irrigation Engineer that it is virtually impossible to keep a college graduate on the farm as an irrigation supervisor. However, good high school diploma people are available and are likely to stay on the farm. Dr. Lindsay and Ms. Topper indicated that this year's irrigation short course is being developed to be more basic and will be geared to students with a high school diploma.

The short course handouts had not been assembled at this time. The consulting Irrigation Engineer requested a copy of the short course handouts be sent to the SBED office. The consulting Irrigation Engineer would be very much interested in looking through the materials.

SUMMARY OF COMMON IRRIGATION CONSTRAINT FINDINGS

Working with the Small Business Export Development Project Clients, the consulting Irrigation Engineer observed common production constraints related to irrigation as follows:

IRRIGATION SYSTEM MAINTENANCE

Water leaks in pipelines and water control valves were observed on all existing operating irrigation systems. Where repair of water leaks were initiated during the consulting Irrigation Engineer's visit, one farm manager expressed his surprise that eliminating water leaks would result in such increased changes in water flows and pressures in the irrigation system.

Numerous broken water control valves were observed. Broken water control valves makes it difficult to adequately turn off and on the proper water flow.

No maintenance scheduling plan, including visual observation techniques, is being employed by any of the farms visited.

Adequate maintenance of an irrigation system is essential for efficient and uniform irrigation water application. The consulting Irrigation Engineer recommended that each farm designate one irrigation worker with the responsibility to continually walk the fields during the time the irrigation system is operating, noting problems and repair requirements. It is recommended that the farm have on hand a supply of replacement supplies so repairs can be made as soon as possible. Replacement parts and repairs are readily available for dealers in the country.

WATER MANAGEMENT

Appropriate measuring devices for efficient irrigation water management have not been installed on most of the irrigation systems or available for the farm irrigation workers. This includes pipeline water flow meters, pressure gauges, soil augers and iron rods.

Irrigators have limited knowledge on quantity of irrigation water being applied per irrigation. Water is being applied until the surface is well wetted and then the irrigation system is shut down. It was the observation of the consulting Irrigation Engineer that in most cases not near enough irrigation water is being applied to meet crop water requirements.

The consulting Irrigation Engineer recommended that a pipeline water flow meter be installed on all irrigation systems, pressure gauges be installed in appropriate places plus the irrigation worker carry a pressure gauge in his pocket where sprinkler systems are used, soil augers and iron rods be made available for determining soil moisture conditions.

The consulting Irrigation Engineer provided training to the irrigation workers management devices.

PURCHASE OF IRRIGATION EQUIPMENT AND SUPPLIES

Most of the farmers purchase an irrigation system and equipment without first obtaining an adequate irrigation design and/or plan for the farm. Every farm the consulting Irrigation Engineer visited that had an irrigation system, purchased it without the dealer having to install it. The reasoning seemed to be that the farm labor was less expensive than the dealer's labor. Many times it was found that the farmer and his irrigation labor didn't quite know how to go about installing the irrigation system and then knowing how to check it out to determine if everything is working properly.

Purchasing an irrigation system in the above way, resulted in some of the irrigation equipment being inadequate for the conditions such as pipes not able to handle the pressure thus, breaking; irrigation pumps delivering water and pressures different from what is required (pumps and irrigation systems not matched), etc.

The consulting Irrigation Engineer recommended that the farmers purchase their irrigation systems on the bases of the dealer supervising the installation. The farmers can still use their farm labor for installing the irrigation systems, but include the supervision of the dealer to insure proper installation.

With the farmers purchasing the irrigation system with the dealer supervision option, it was also recommended that a final payment not be made for the equipment and supplies until the farmer is satisfied that the irrigation system operates as agreed upon at time of purchase.

The farmers seemed to have a limited knowledgeable of irrigation equipment, supplies and services that are available in the country. For example, the farmers that already have an irrigation system where unaware that replacement parts and supplies are available here in the country. Also, those farmers interested in purchasing an irrigation system, seemed to be unaware that the dealers in Jamaica provide a free design and cost estimate service, and installation and supervisory service for a cost and that the necessary supplies are available in country instead of looking to the States for purchase, maintenance and repairs. Everyone felt that the dealers in the country provided services only for the large estates.

Purchase of equipment in the country also insures the local dealers having on hand replacement parts for the irrigation systems they sell.

The consulting Irrigation Engineer visited with the 4 Jamaican irrigation companies and suppliers. Though the visits where brief, it appears the irrigation companies and suppliers in the country can provide all the necessary irrigation services for the Jamaican farmers.

Where groundwater is the source of water, the farmers have a very limited knowledge on how to work with an irrigation well driller on drilling, developing and pump testing a well. Most all the irrigation pumping plants visited were selected by "what someone thought" was the amount of water the well would yield and at what depth.

On one of the farm's, the well is yielding a large quantity of silt with the water. The well driller should have developed and pumped the well with his own pumping equipment until the silts had all been pumped from the well. Silts in the water cause significant wear in an irrigation pump which the farmer will experience own pump.

RECOMMENDATIONS TO THE SMALL BUSINESS EXPORT DEVELOPMENT PROJECT

* It may be well to have a consulting Irrigation Engineer be assigned to return in about 6 months to revisit the farms visited during this assignment. Many irrigation methods, techniques and changes to managing the irrigation systems and steps for purchasing irrigation systems were made by the consulting Irrigation Engineer. However, once the farmers and their irrigation workers have the opportunity to implement the recommendations, many follow-up questions will result. It ,too, will be important to know if the recommendations have been implemented and if not, why not. It is key to implement the irrigation recommendations that have been made to the farms visited for efficient operations of their irrigation systems and to realize maximum benefits as a result. All the recommendations, if implemented, will have a positive impact on each farms production.

* During some periods of the irrigation season, irrigations will need to be done during the night on several of the farms visited. Concern was expressed by the General Farm Managers, indicating that it would be difficult to get reliable farm labor as night time irrigators. The consulting Irrigation Engineer has recommended that incentives be paid (increased pay) for those farm worker who are hired for night time and/or holiday irrigation. The consulting Irrigation Engineer is uncertain how this fit Jamaican culture and will be curious if this recommendation is carried out. However, it is a must on some farms to do night irrigation or on holidays because of limited water supply.

* Also, two of the last visits made by the consulting Irrigation Engineer, time did not permit to do full justice to address, in depth the irrigation needs. The two last visits were made to Mistflora, Ltd. (Mrs. Dawn Ottey) and Tropicrop/Mushrooms Ltd./Kircamp Properties Ltd. (Mrs. Jennifer Lyn). A one day visit was made to each of the farms. Much longer time is required to address their irrigation needs.

* It would be well for a consulting Irrigation Engineer work directly with the irrigation dealers and suppliers in Jamaica. The farmers questioned some of the things that the consulting Irrigation Engineer was told by the irrigation dealers and suppliers during his visit with them. It would be interesting to visit farms with the dealers where they have provided their services.