Iqaluit Greenhouse Feasibility Study
Type of Study: Primary Production Agriculture, Greenhouses
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IQALUIT GREENHOUSE FEASIBILITY STUDY

for

The Department of Economic Development and Tourism
Government of the Northwest Territories
Iqaluit, N.W.T.

by

Burdett-Moulton Architects & Engineers Ltd.
Dean Hay, Market Analyst
Mark Romer, Horticulturalist
MacKay & Partners, Chartered Accountants

October, 1988

DRAFT

Northwest
Territories Baffin Region

**ECONOMIC DEVELOPMENT
& TOURISM**
File #: 4042

November 07, 1988

Jacques Belleau
Frobuild Construction Ltd.
P*O. Box 133
IQALUIT, N.W.T.

Dear Jacques.

Iqaluit Greenhouse Feasibility Study

I have read the study and find it quite good and comprehensive. There are a few suggestions and observations, however, which I would like to make (some in fact were made previously both verbally and in writing).

1) Mater costs are estimated $1,200. for a year. Has the Town ratified this? It seems low to me.

2) Wages are based on one person-year. This may be unrealistic from both a dollar perspective and in terms of labour/management requirements. The study notes that a skilled person would be needed because of the exacting requirements for production scheduling, maintenance, nutrient balance, etc. Assuming $15,000. Is used for local labour, that would only leave $30,000. for wages, wage costs, housing allowance and other beneffts for the Manager. I also do not think the t4anager/horticulturist could reasonably work elsewhere in a shared-employee scenario.

3) The 15% premium for locally-grown produce should be ratified by the local retailers. I'm not sure Arctfc Ventures would be willing to pass the higher price (say 20%) on to thefr consumers. Arctic Ventures once remarked to me that wfth the good jet service thefr losses to spoilage are quite low. This 15% premium might only work if all retailers carried only the local produce, or it they all carried both, with the northern-grown produce being identifiable through promotional packaging, etc.

Also, I am curious about your method for computing wholesale values for the produce from retail values. Again, we have the 15% premium assumption as well as an assumption that institutions will pay full retail value plus 15%.
The" fnstftutions are in the habit of buying wholesale or by tender to get the lowest possible price. G.N.W.T. purchases produce for the Correctional

Center from the Bay and Arctic Ventures on a tender basis. Therefore, Institutions would pay 10 - 15% less than retail if they bought from local retailers. A greenhouse attempting to sell directly to institutions would have to be competitive with other suppliers, and do so at risk of losing part of the local wholesale market.

4) The values calculated for produce are based on volume and price assumptions that are quite liberal to say the least; e.g. demand for cucumbers and the price for lettuce, also the assumption that there will be a demand equivalency between Iceberg head lettuce and leaf lettuce.

5) In your financial analysis, I would ask about the 'shareholders loan" component of the financing program. EDA and basically all funding programs have an equity requirement which does not allow any interest repayment, but normally which would help generate a return in revenues to the business. A shareholders loan could compliment but not replace equity, which can range from 10 - 20% depending upon the program, to help reduce long-term debt.

Would it be possible to have another financing program scenario showing total project costs, minimum equity (say 10%), and determine what level of grant-funding would be required to compliment what level of long-term debt to give you a 12% return on your greenhouse business (as opposed to on your loan to the greenhouse business?).

I found the financial analysis somewhat confusing. A better summary and a clearer progression of Ideas building the case for a certain level of grant funding would go a long way.

Finally, can we receive the accounting for this contribution as soon as possible as per Appendix 1 in the Contribution Agreement?

A lot of work has been done on this study and I think it is a major accomplishment. 1 believe the decision as *to* whether or not to apply for EDA funding is yours; e.g. does it make sense as an investment, given your other priorities. Certainly we would like to see it 'go".

It is difficult to foresee how EDA would respond given the high government contribution relative to employment created. It would be nice if funding agencies would agree on a way of computing the value of import displacement that transcends the normal economic cost/benefit analysis.

In any case, let us know if you decide to pursue funding and if we can assist in any way.

Sincerely,

Larry Simpson
Supervisor, Renewable
Resource Development

cc Rick Moulton

LS/jh

CONTENTS

EXECUTIVE SUMMARY

A "Study of Vegetable Markets in Selected N.W.T. Communities" was carried out for the Department of Economic Development and Tourism, Government of the Northwest Territories in August, 1986. This study recommended the investigation and possible construction of a greenhouse in Iqaluit.

The Department of Economic Development snd Tourism advertised in January, 1987, an invitation to prospective developers to submit proposals for a greenhouse investigation in Iqaluit. The successful proposal was submitted by Frobuild Construction Ltd. who designated a consultant team, headed by Burdett-Moulton Architects & Engineers Ltd. in association with Dean Hay, Market analyst; Mark Romer, Horticulturalist; and Mackay & Partners, Chartered Accountants. This consultant team was thus retained to conduct this study that is intended to determine the commercial feasibility of establishing a greenhouse, using existing and tested technology, in Iqaluit.

1. Objectives of the Study

There are a series of requirements and objectives which this feasibility study is intended to fulfill. More specifically these include the following:

- to determine the types, quantities and quality of vegetables in demand in Iqaluit and to establish the market prices, seasonal variations and effects of greenhouse enhanced quality on consumer demand.

- to determine the availability of waste heat and siting possibilities, to research climate conditions in Iqaluit, and to research greenhouse systems.

- to investigate possible government, private foundation, or agency funding programs for technology and/or personnel training.

- based on the initial market study, to perform a horticultural design and production scenario study including plant propagation, crop management, and economics.

- to develop greenhouse designs, and to determine the capital and operating costs, and the economic feasibility for each production scenario.

- o to develop a final design/production model with growing plan and operating system, conceptual drawings, energy calculations, capital and operating costs, and proforma financial statements to demonstrate viability.

2. METHODOLOGY

Contained in this report are five individual reports undertaken to meet the objectives of the study. In accordance with areas of expertise, the following studies were performed and are presented in chronological order in this report:

- o PART 1 - PRE-FEASIBILITY ASSESSMENT

  This study was undertaken by Burdett-Moulton Architects & Engineers Limited. The availability and potential usage of waste heat were investigated. A locational analysis was performed and siting criteria for the greenhouse were developed. Further, the climatic conditions of Iqaluit, including prevailing winds, snow drifting, and solar radiation, as they apply to the siting and operation of a greenhouse were determined.

- o PART 2 - MARKET STUDY

  Through a consultation program, Mr. Dean Hay determined the demand for , types, quantities and prices of produce in Iqaluit. The retail and wholesale prices of the desired produce was determined. Based on the opinions of the people interview, the impact of seasonal prices and availability was accessed. Further, these opinions were used to estimate the degree of price sensitivity for locally produced greenhouse vegetables as compared with imported vegetables.

- o PART 3 - HORTICULTURAL DESIGN AND PRODUCTION SCENARIOS

  This study was undertaken by Mark Romer. Initially, an analysis was performed comparing soil and hydroponic growing systems in the Arctic environment. Three hydroponic systems were selected and evaluated. The vegetables identified in the market study were assessed from an economic and horticultural viewpoint. Based on this assessment three crops were selected. Production scenarios were developed for the crops indicating temperature, lighting, and other production requirements. Capital costs were estimated for the growing, CO_2, and lid~t-ing system of each production scenario. Similarly, operating costs were estimated for labour, growing supplies, equipment, electrical power, and water.

- PART 4 - ENGINEERING DESIGN, CAPITAL AND OPERATING COST ESTIMATES

  Using available premanufactured greenhouse structures, Burdett-Moulton Architects & Engineers Ltd. developed a greenhouse design appropriate for Iqaluit. Based on the design, waste heat availability, and climatic conditions, a site was selected for the greenhouse. Capital costs were estimated for two sizes of greenhouses both with and without a waste heat recovery systems. Income and operating expenses were estimated for two sizes of greenhouse, both with and without waste heat, and for three growing scenarios.

  Potential funding sources for the project are listed. The observations and opinions of a number of greenhouse operators in the north are summarized.

- PART 5 - ECONOMIC ANALYSIS

  Based on the information provided in the previous reports, Mackay & Partners , Chartered Accountants, calculated proforma income statements and a cash flow projections for eight years for eight greenhouse operating scenario. The most feasible scenario was further examined to determine the level of government funding required to produce a viable operation.

3. SUMMARY OF FINDINGS -

The findings and recommendations that can be drawn from the five studies are as follows:

1. Sufficient waste heat is available from by the Northwest Territories Power Corporation's generating power plant to heat a greenhouse complex under design renditions. The Power Corporation will allow the waste heat to be used if the capital rests for installation of the recovery equipment are revered by the developer.

2. Consumers , retailers, restaurants, hotels and caterers in Iqaluit are prepared to pay 15% more than current retail prices for fresh, high and consistent quality produce grown in a local greenhouse.

Institutions are equally prepared to paY a similar price increase; however , the volume of produce required would have to be met consistently before orders could be placed at a local greenhouse.

3. There are three hydroponic growing systems suitable for Iqaluit:
   - o nutrient film technique culture,
   - o peat bag culture, and
   - o rock wool culture .

   Since the capital and operating costs are least expensive, the nutrient f ilm system is recommended.

4. The most suitable greenhouse crops for Iqaluit are tomatoes, lettuce and Cucumbers . Tomatoes and cucumbers are cliff icult and expensive to cultivate during the winter, therefore an 8 month cultivation season is recommended. Lettuce is easier to grow and a 12 month cultivation season is recommended.

5. Sunlight from a northerly direction is important and should be considered in the design of a greenhouse for the Arctic. During the winter months a greenhouse could only be operated with the use of artificial lighting.

6. A multi-span greenhouse with double glazed acrylic walls, a double glazed polyethylene roof , and a gravel floor provides an economical system suitable for Iqaluit.

7. A site located near the power generating plant, and thus the source of waste heat, provides a suitable location for a greenhouse complex.

8. The Capital Cast for two sizes of greenhouse both with and without waste heat recovery are as follows:

	7500 ft^2	10,000 ft^2
with waste heat recovery	$530 ,000.00	$600,300.00
no waste heat recovery	$411,000.00	$481,300.00

A 7,500 ft^2 greenhouse is large enough to provide 50% of current market demand and a 10,000 ft ^{2} would provide 75%.

9. Based on the market prices of produce established in the market study, the operating costs established in the horticultural and engineering studies and the assumption that the project will be financed by a long term debt with rates at 12% per annum compounded semiannually the first year revenue and expenses of eight different greenhouse scenarios are as follows:

	Income	Expenses
1. Option 1 (7,500 ft², with waste heat recovery, 8 months lettuce, tomatoes and cucumbers)	$ 78,135.00	$112,767.00
2. Option 2 (7,500 ft², no waste heat recovery, 8 months lettuce, tomatoes and cucumbers)	$ 78,135.00	$112,119.00
3. option 3 ('7,500 ft², with waste heat recovery, 12 months lettuce, and 8 months tomatoes and cucumbers)	$103,935.00	$128,882.00
4. Option 4 (7,500 ft², no waste heat recovery, 12 months lettuce, and 8 months tomatoes and cucumbers)	$103,935.00	$137,244.00
5. Option 5 (10,000 ft², with waste heat recovery, 8 months lettuce, tomatoes and cucumbers)	$104,180.00	$129,232.00
ii. Option 6 (10,000 ft², no waste heat recovery, 8 months lettuce, tomatoes and cucumbers)	$104,180.00	$136,084.00
7. Option 7 (10,000 ft², with waste heat recovery, 12 months lettuce, and 8 months tomatoes and cucumbers)	$138,580.00	$149,947.00
8. Option 8 (10,000 ft², no waste heat recovery, 12 months lettuce, and 8 months tomatoes and cucumbers)	$138,580.00	$169 ,409.00

10. An anal ysis with proforma income statements, balance sheets and cash flow statements indicates that Option 7 (10,000 ft², with waste heat

recovery, a 12 month lettuce growing season, and an 8 month tomatoe/cucumber growing season) is the best of the 8 options, however none of the options provides a positive cash flow after eight years of operation. The following table provides a summary of the cash flow totals a the end of eight years for each of the options:

Description	Cash Deficit
Option 7 (10,000 ft^2, waste heat recovery, 12 months lettuce, 8 month tomatoes/cucumbers)	($538,986.00)
Option 3 (7,500 ft^2, waste heat recovery, 12 months lettuce, 8 months tomatoes/cucumbers)	($661 ,634.00)
Option 5 (10,000 ft^2, waste heat recovery, 8 months lettuce, tomatoes and cucumbers)	($668,389.00)
Option 8 (10,000 ft^2, no waste heat recovery, 12 months lettuce, 8 months tomatoes/cucumbers)	($725 ,003.00)
Option 6 (10,000 ft^2, no waste heat recovery, 8 months lettuce, tomatoes and cucumbers)	($733,019 .00)
Option 4 (7 ,500 ft^2, no waste heat recovery, 12 months lettuce, 8 months tomatoes/cucumbers)	($741 ,652.00)
Option 2 (7 ,500 ft^2, no waste heat recovery, 8 months lettuce. tomatoes and cucumbers)	($746,428. GO)
Option 1 (7 ,500 ft^2, waste heat recovery, 8 months lettuce, tomatoes and cucumbers)	($752,444 .00)

11. Given the projected income, expenses and cash flows , a significant grant would be required to make a greenhouse operation viable in Iqaluit. A further analysis of option 7, indicates that each of the following financing arrangements would provide a positive cash flow after 8 years of operation.

Option A	*Shareholder Loan	$200,000.00
	Government Grant	$300,000.00
	Lang Term Debt	$100,300.00

Option B	*Shareholder Loan	0.00
	Government Grant	$380,000.00
	Long Term Debt	$220,300.00
Option C	*Shareholder Loan	$100,000.00
	Government Grant	$340,000.00
	Long Term Debt	$160,300.00

12. The projected cash flow for these three options follows:

Year	Closing Cash		
	Option A	Option B	Option C
1	($2,853.00)	($2 ,037 .00)	($2,445.00)
2	($4 ,880.00)	($2,048.00)	($3,464.00)
3	($6,042.00)	$ 66.00	($2,988.00)
4	($6 ,294.00)	$ 228.00	($ 940.00)
5	($5,591 .00)	$ 479.00	$2,758.00
6	($3 ,885 .00)	$1,408.00	$6,349.00
7	($1 ,125 .00)	$3,096.00	$7,426.00
8	$2,987'.00	$6,254.00	$9,421.00

* No specific terms for repayment, rate at 12% compounded semiannually.

REPORT

IQALUIT GREENHOUSE PRE-FEASIBILITY ASSESSMENT IQALUIT, N.W.T.

DEPARTMENT OF ECONOMIC DEVELOPMENT
AND TOURISM
GOVERNMENT OF THE
NORTHWEST TERRITORIES
IQALUIT, N.W.T.

BURDETT-MOULTON
ARCHITECTS & ENGINEERS LTD.

IQALUIT GREENHOUSE PRE-FEASIBILITY ASSESSMENT

INTRODUCTION

The purpose of this study is to determine whether there is waste heat available for a greenhouse operation in Iqaluit, how to utilize this waste heat if it is available, where the greenhouse complex can best be located; and the major recorded climatological factors that will affect the operation of a greenhouse.

To address these issues, we had a number of discussions with Northern Canada Power Commission (N.C.P.C.) personnel in Iqaluit and Edmonton. We also discussed potential sources of waste heat with the Town Engineer, and with the Department of Public Works and Highways. The system for dumping waste heat from the N.C.P.C. generators was reviewed and the potential greenhouse sites around the power plant examined. Finally the pertinent climate data was obtained from the local meteorological station and we discussed it with experts at the National Research Council in Ottawa. The following report summarizes our findings.

WASTE HEAT AVAILABILITY

Most sources of waste heat available in Iqaluit are in the form of exhaust air from building . There are only a few cases where large exhaust systems operate 24 hours a day. These systems exhaust air at room temperature or slightly higher and therefore the heat content of the medium is too limited to heat a greenhouse complex of any size. For these reasons, systems such as the Ukkivik Residence ventilation were not investigated further.

Another potential source of local waste heat available is the proposed Municipal Incinerator. Unfortunately, the Town Engineer indicates that this project will not take place in the near future.

The most logical source of waste heat in Iqaluit is the N.C.P.C. electrical power generating plant. This plant produces more heat than required for the proposed [illegible] and produces it on a reliable basis.

EVALUATION OF WASTE HEAT FROM N.C.P.C

The main plant has three generators: a kV12, a kV8
The kV12 is the prime generator used during the wir

the kV8 is the prime generator during the summer months, and the kV6 is used as a spare and to supply excess capacity as required. There is also another generator called the E.M.D., located on a separate site, that is used for spot service.

Since the kV6 is on a separate air-cooled system and operates irregularly, it *was not* considered as a reliable source of waste heat. For the same reasons and because it is located on a different site, the E.M.D. was not considered.

At an average load capacity, the kV8 jacket cooling water produces approximately 1.7 million BTU per hour and the kV12 produces approximately 3.0 BTU million per hour. A rough estimate indicates that there is sufficient heat from the kV12 for a solar greenhouse (see figure 1) of 3000 m² based on a design temperature Of -40°F.

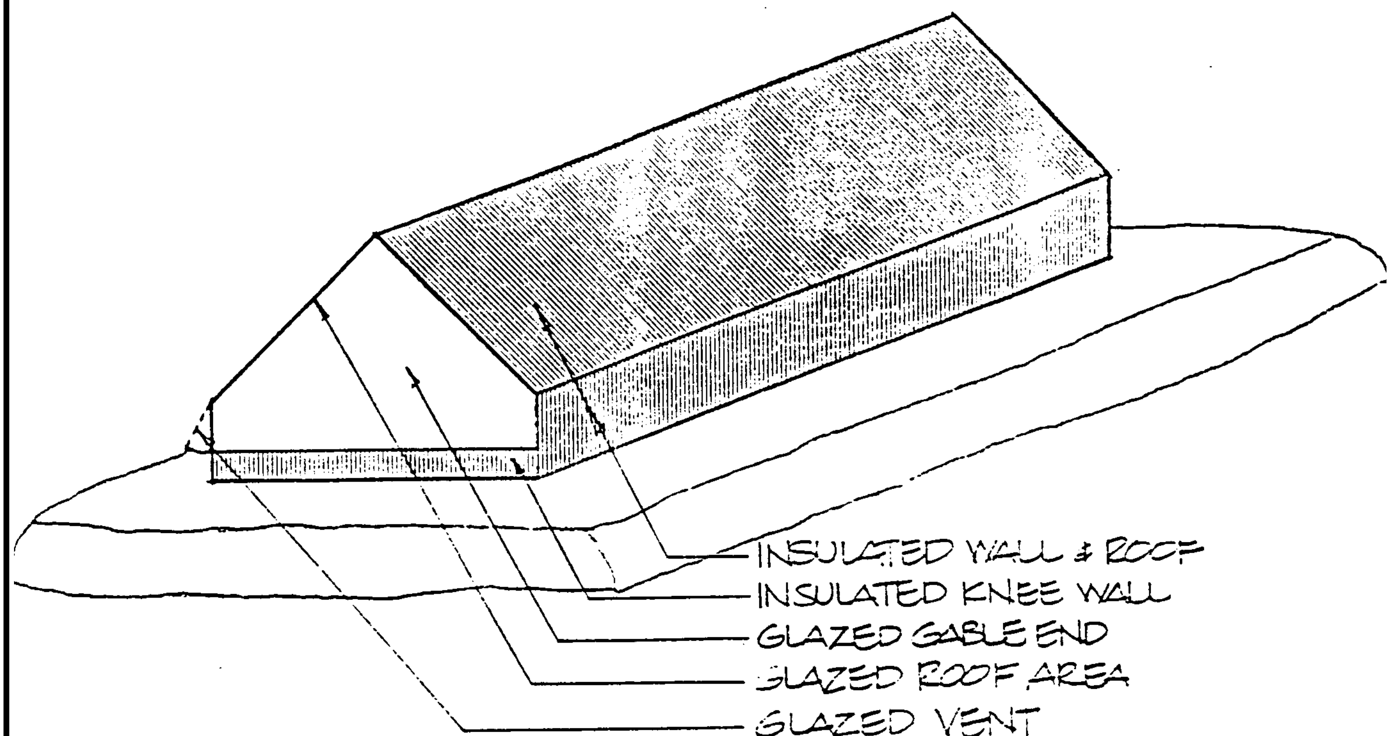
The kV12 and the kV8 generators are cooled by water From Lake Geraldine and then the water is recirculated back to that lake. This water is supplied at approximately 35°F and returns at a maximum temperature of 135°F. At these temperatures. it is difficult to provide sufficient heat for , the greenhouse complex.

The jacket cooling water from the generators leaves at 180°F, goes to heat exchangers, looses heat to the water from Lake Geraldine and returns to the generator jacket at temperatures. between 160°F and 170°F. This circuit is at a higher temperature and therefore the heat is more easily utilized for heating the greenhouse complex.

There appears to be two possible methods for tapping the waste heat source at N.C.P.C. :

- To install a flat plate heat exchanger upstream of the lake water heat exchanger in the jacket water cooling circuits for both the kV12 and the kV8 electrical generators.

- To change the flow characteristics of the water to and from Lake Geraldine and upgrade the return temperature to about 165°F. The return water could then be used directly to heat the proposed greenhouse project. This would eliminate the cost of the flat plate heat. exchangers, provide further separation between the generator system and the greenhouse heating system, and the waste heat from all cooling heat exchangers (including cooling oil) for the generators would be available for the project. The characteristics of the existing heat exchangers would have to be checked thoroughly during the design stage to verify that this solution is feasible.



TYPICAL GREENHOUSE FIGURE 1

N.T.S.

project "''" IQALUIT GREENHOUSE		
job title: TYPICAL GREENHOUSE		job no:
BURDETT-MOULTON **ARCHITECTS & ENGINEERS** P.O. Box 631 FROBISHER BAY (IQALUIT), N.W.T. XOA OHO (819) 979-6539	dwn by: BC	scale: N.T.S ,
	chk'd by: RM	date: 12 FEB 88
	sgn'd by:	dwg no: 31&J. 1

In our discussions with NCPC, they have indicated that they prefer the first solution using the heat exchangers. This method has been used in previous heat recovery projects and NCPC are familiar and confident with it.

The controls for the new piping circuits will be in the N.C.P.C. generating station and will be set up such that if they endanger the electrical generating system in any way, they can be completely by-passed. The change to the existing generating system will be kept to a minimum.

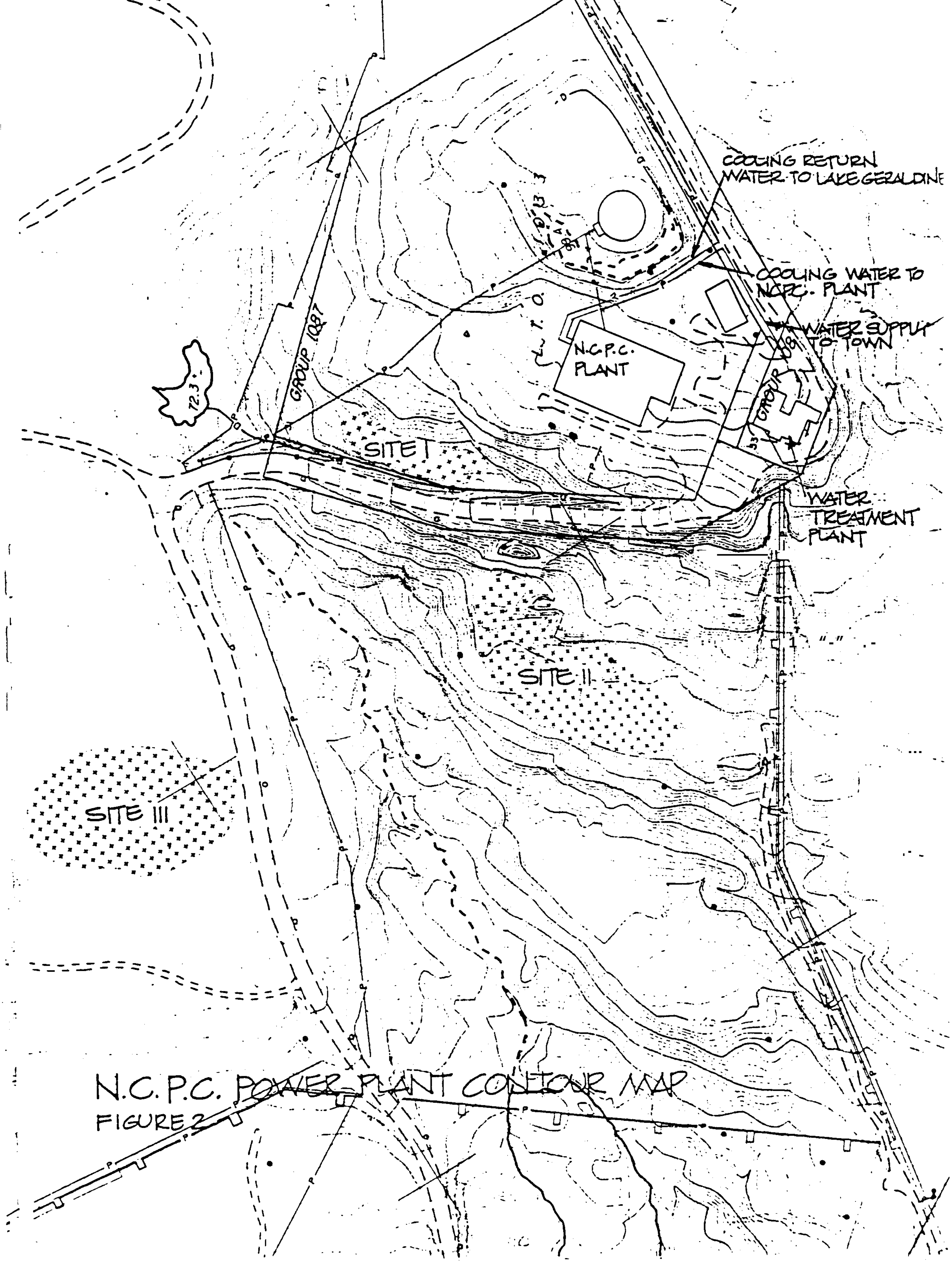
At present all the waste heat from the jacket water cooling goes into Lake Geraldine and there has been some concern expressed about the security of the Municipal water supply if some of this heat is diverted elsewhere. The Town Engineer and the Consultant who did the Lake Geraldine Water Level Analysis a few years ago do not feel that this will be a problem. The study assumed a 1.5 meter ice allowance.

N.C.P.C.'s general policy with respect to waste heat recovery is that the waste heat is free, the client must provide all capital costs, and the system must not endanger the electrical generating system. Enclosed as an appendix to this report is a letter from N.C.P.C. verifying their support for this project.

SITING ANALYSIS

There are a number of factors that have to be taken into account when considering where the greenhouse complex should be located. If it is assumed that waste heat recovery is an essential element for a viable operation, and that the N.C.P.C. power plant is the only reasonable source of this heat, then the proposed complex must be placed near this plant. The site should also have a good southerly exposure; be sheltered from the prevailing winds; be close to water, sewage waste facilities, and electricity; be easily accessible by truck and perhaps the public; and be compatible with the Zoning Bylaw of the Town of Iqaluit. There must also be a provision for future expansion of the complex.

Figure II is a site plan of the area immediately surrounding the N.C.P.C. power plant and identifies three possible building sites. All three sites have a good southerly exposure, are sheltered from the prevailing winds, and have electricity readily available. Sewage services to the sites will have to be by sewage pump-out truck.



N.C.P.C. POWER PLANT CONTOUR MAP
FIGURE 2

Site I is the closest to the plant and therefore has the least piping costs for using the waste heat. It is also reasonably near the water supply and the location is easily accessible. Unfortunately, this site is part of power plant land and time and effort would be required to acquire it. The chief deficiency of this site is that there is sufficient room for only a small greenhouse and no room for expansion.

Site II has somewhat higher piping costs and Is a very awkward site to access. There is little level land and the buildings would all have to be constructed on piles. There is room for expansion. It too is not far from the water supply but sewage pump-out might be difficult because of the awkward site and the lift required.

Site 111 is the most accessible and the topography is "reasonably level for building and expanding, but it has the largest development costs. Long runs of piping would be required to run to the power plant and to connect to the town water supply.

CLIMATOLOGICAL INFORMATION

The following information for Iqaluit was obtained from the local office of Environment Canada. The term "Global Solar Radiation on a Horizontal Surface" means the total incoming direct and diffuse (such as coming from clouds) short-wave solar radiation received from the whole dome of the sky on a horizontal surface.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
TOTAL BRIGHT SUNSHINE (HOURS)	35.2	96,3	177.4	235.3	199.9	17S.2	202.1	161.2	82.4	57.8	45.6	19.6
MEAN DAILY GLOBAL SOLAR RADIATION ON A HORIZONTAL SURFACE (MJ/m²)	0.84	3.52	9.19	17.61	21.20	19.74	16.42	12.81	7.42	3.31	1.14	0.39
MEAN DAILY TEMPERATURE (°C)	-25.6	-25.9	-21.7	-14.3	-3.2	3.4	7.6	6.9	2.4	-5.0	-13.0	-21.8
MEAN DAILY MINIMUM TEMPERATURE (°C)	-29.7	-30.3	-27.5	-19.1	-6.6	0.3	3.1	3.4	-0.3	-7.8	-16.9	-25.9
MEAN DAILY MAXIMUM TEMPERATURE (°C)	-21.5	-21.S	-17.9	-9.4	0.2	6.6	11.4	10.3	5.0	-2.1	-9.0	-17.6

MEAN HOURLY GLOBAL SOLAR RADIATION ON A HORIZONTAL SURFACE IN IQALUIT (MJ/m²)

	HOUR																			
	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	2?
JANUARY							0.01	0.05	0.15	0.21	0.22	0.15	0.05	0.01						
FEBRUARY						0.03	0.16	0.37	0.5S	0.66	0.67	0.55	0.S6	0.15	0.02					
MARCH				0.01	0.09	0.33	0.65	0.96	1.21	1.3S	1.34	1.21	0.98	0.66	0.33	0.09	0.01			
APRIL			0.04	0.22	0.54	0.94	1.36	1.71	1.97	2.09	2.09	1.94	1.67	1.S2	0.93	0.53	0.21	0.04		
HAY	0.01	0.06	0.21	0.47	0.81	1.19	1.58	1.94	2.15	2.28	2.26	2.12	1.88	1.56	1.19	0.S2	0.38	0.22	0.06	0.01
JUNE	0.04	0.13	0.29	0.52	0.81	1.12	1.43	1.67	1.87	2.00	1.99	1.90	1.70	1.45	1.14	0.84	0.5S	0.31	0.13	0.04
JULY	0.02	0.08	0.20	0.39	0.61	0.91	1.21	1.46	1.62	1.70	1.69	1.62	1.45	1.21	0.94	0.67	0.42	0.22	0.08	0.02
AUGUST		0.01	0.07	0.20	0.42	0.67	0.95	1.19	1.39	1.46	1.46	1.39	1.19	0.98	0.72	0.46	0.23	0.06	0.01	
SEPTEMBER				0.03	0.14	0.32	0.55	0.76	0.91	1.01	0.99	0.93	0.74	0.54	0.33	0.13	0.03			
OCTOBER					0.01	0.05	0.18	0.36	0.50	0.59	0.59	0.49	0.36	0.18	0,05	0.01				
NOVEMBER							0,02	0.09	0.20	0.27	0.26	0.20	0.09	0.02						
DECEMBER								0.01	0.06	0.11	0.12	0,06	0.01							

SUMMARY

The N.C.P.C. power plant is the only reasonable source of waste heat for this project. There are two alternatives to recover the waste heat from the generators. The solution which is preferred by NCPC is to install heat exchangers directly into the jacket cooling water circuits for the generators. Regardless, N.C.P.C. are in agreement with the concept of the project and there is sufficient waste heat available for a large greenhouse complex.

It appears that the choice is between Site II and Site III and will be based upon the costs of developing each site. At this stage, the Town does not foresee a problem with either of these sites. The final selection will have to be made later in the design process when accurate estimating is possible.

The climatological data indicates a dramatic reduction in hours of sunshine and consequently in radiation from the sun during the winter. If the greenhouse operation is to carry through the winter, it will have to rely mainly on artificial lighting.

At this stage in the process, there doesn't appear to be any engineering reason why this greenhouse project could not be successful.

NORTHERN
CANADA
POWER
COMMISSION

COMMISSION
D'ENERGIE
DU NORD
CANADIEN

P.O. Box 250
Iqaluit, NWT
XOA OHO

RECEIVED FEB 25 1988

Tuesday February 23rd, 1988.

Burdett - Moulton, Architects & Engineers Inc.
P.O. Box 609
Iqaluit, NWT
XOA OHO

ATTENTION: Mr. Rick Moulton, P. Eng.

RE: NCPC POLICY ON RESIDUAL HEAT

This will acknowledge your February 19th, 1988 "telecon" request for information stating N. C. P.C.'s position on residual heat.

love looked around the office for something in writing which i could pass on to you, but have not been successful. I shall however, continue and when I do find what I'm looking for, I'll send it along.

in the interim, perhaps the following personal interpretation will be of some benefit. it is my understanding that N. C.P.C. considers residual heat to be that portion of heat energy rejected (approx. 28%) by the process to the jacket water or cool ing system. Historically, it has been N. C. P.C.'s practice to make this residual heat available, at a nominal fee, to clients who have the plant and expertise to utilize it. N. C.P.C. will not bear any of the capital costs involved in reclaiming this residual heat nor will it guarantee a specific or uninterruptible supply of heat energy. Any proposal put forward by the client must conform to all Federal, Provincial/ Territorial and Local Codes, Standards, etc. and all workmanship must be consistent with good trade practices.

There may be some minor terms and conditions that I've overlooked here, but I think the foregoing points touch on all the major criteria. I trust this will be helpful, but should further clarification be required, do not hesitate to contact the undersigned.

I remain.

Respectfully Yours,
Northern Canada Power Commission "

John Sullivan, C.E.T.
Engineering and Maintenance Manager, NWT (East)

JS/nd

MARKET STUDY

for a

COMMERCIAL GREENHOUSE

in

IQALUIT, N.W.T.

Prepared for: GOVERNMENT OF THE NORTHWEST TERRITORIES
ECONOMIC DEVELOPMENT & TOURISM

by: DEAN HAY
P.O. 1300
IQALUIT, N.W.T.
XOA OHO

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GREENHOUSE MARKET SURVEY DATA

INTRODUCTION

The purpose of the survey was to determine the **characteristics of market** demand for fresh vegetables in Iqaluit.

Specifically, the researcher was charged with:

1. identifying the types of vegetables in demand
2. determining market demand with respect to volumes and retail market values by variety and by market sector including retail, restaurants and hotels and government funded institutions.
3. estimating the impact on demand of seasonal price and availability variations
4. estimating the impact on demand of greenhouse-enhanced product quality and the degree of price sensitivity for greenhouse produce as compared to imported produce.

With these directions, we compiled a list of all relevant potential respondents for individual interviews. Of these, **75%** agreed to take part in the survey. In addition,. random interviews with shoppers were conducted producing an additional 10 **reponses. All** responses *were* personally interviewed; no surveys were mailed or filled in without the respondent being able to clarify all aspects of questions which may appear ambiguous on first reading.

A breakdown of respondents follows:

NUMBER OF RESPONDENTS ....28.........

SUPPLIERS. ....4... .. .CONSUMERS. ..17.. ..Business. ..7...

Suppliers:	The Bay Arctic Ventures Marche Turenne Amblers IGA
Consumers:	Private individuals Gov't. funded institutions
Businesses:	Frobisher Inn Kamotiq Inn Navigator Inn The Snack Restaurant Discovery Lodge Bayshore Hotel Versa Foods (Baffin Reg. Hospital>

To determine the Representative Sample, we asked how many individual meals were prepared daily by each respondent. We then took the total population figure and assuming three meals a day each, determined the percentage our results represented.

(Note: Two major restaurants would not divulge their daily individual meal total and one of those refused to disclose quantities ordered. Consequently, the total above is lower than the quantities later represent and the representative sample immediately following is proportionately higher. For our purposes and based on figures available from other similar businesses, it would be safe, in our opinion, to to assume that an additional 200-250 meals per day are being served from these establishments. This would in turn increase the perceived representative sample to approx. 15.4%)

REPRESENTATIVE SAMPLE SURVEYED

Population of Iqaluit . . . . approx.	3,000
Total of meals @ 3 / day	9,000
Total of meals prepared by survey respondents	1,165
Representative Sample	13%

Respondents were questioned during Nov. 1987 and Jan. 1988. Their responses are indicative of that period only; increased population during summer construction months would result in higher demands than herein indicated.

Response to the concept in general was very positive. Respondents expressed unanimous opinion that availability of better quality vegetables was deired and long over-due. This is reflected in the responses to the purchasing priority factors at the end of the questionnaire.

Businesses and institutions were primarily concerned with consistent quality as food cost/productivity is paramount in commercial operations. In addition, all but one were in favour of the project and supportive even at a higher cost if it benefitted Northern Business.

PURCHASING HABITS

While the survey asked for quantities purchased on a weekly, monthly or occasional basis, the majority (69%) indicated a weekly shopping preference. This was particularly true in both the business and institutional responses. This led us to tabulate anticipated fresh produce sales as a weekly sales product with only those types suitable for extended storage life as monthly or occasional purchases. .e.g. sealift or. luxury items.

QUANTITIES AND VALUES

The following table represents the total volumes of the different vegetable types surveyed imported into Iqaluit weekly. The table is composed of five columns:

1. Total supplied by The Bay, Arctic Ventures, Amblers IGA and Marche Turenne for private consumers purchases.

2. Totals purchsed **by** Business & Institutions through various Southern suppliers.

3. Total volumes of Col. 1 & 2

4. Unit prices in Iqaluit as of Jan 29 ’88

5. Total values of vegetables purchased according to Jan. 88 prices.

NOTE: The only significantly high price at this time was for lettuce which was at $3.44 ea. **An average price might be more realistically about $2.50 per head.**

Vegetable type	**1**		**2**	**3**	**4**	**5**
Tomatoes	305	lb.	344	649	$2.14 lb.	1388.86
Lettuce Iceberg	282	head	233	515	3.44 ea.	1771.60
Lettuce Romaine	33	-	163	196	3.86 ea.	756.56
Cucumbers (regular)	111	lb.	226	337	1.49 lb.	502.13
Cucumbers (English)	58	"	10	68	4.08 lb.	277.44
Cabbage	87	"	298	385	1.55 lb.	596.75
Potatoes	2400	"	845	3245	11.98 10 lb.	3887.51
Carrots	’252	"	323	575	1.43 lb	822.25
Spinach	15	"	5	20	3.50 lb.	70.00
Brussel Sprouts	25	"	16	41	2.33 lb.	95.53
Onions (cooking)	252	"	273	525	1.53 lb.	803.25
Broccoli	73	head	72	145	2.54 **head**	**368.30**
Peppers (green)	116	lb.	136	252	**2.19 lb.**	**551.88**
Peppers (red)	18	"	8	26	**2.23 lb.**	**57.98**
Cauliflower	41	head	70	111	**6.40 ea.**	**710.40**
Frozen Peas	200	lb.	60	260	**2.72 lb.**	**707.20**
Frozen Beans	102	"	30	132	**2.90 lb.**	**382.80**
Celery	264	stalks	75	339	**1.96 ea.**	**664.44**
Zucchini	3	ea.	30	33	**($ not avail)**	
Egg Plant	0	-	14	14		
Radishes	16	bunch	24	40	**2.13** lb.	85.20
Parsley	13	"	45	58	.69 bunch	40.02
Turnips	68	ea.	15	83	2.90 ea.	242.36
Green Onions	51	bunch	10	61	1.04 bunch	63.40

We wanted to determine where vegetables are purchased, locally or from southern suppliers. As the following figures demonstrate, business (including in this case Gov't. funded institutions) all buy their produce from southern suppliers. The primary supplier for Iqaluit is H. Fine & Sons, Ottawa. Four other suppliers were named, National Grocers, Ottawa, Marche Turenne, Montreal, L'Arrivee, Montreal and Quattrouchi Grocers, Smith Falls, Ont.

Consumers using food orders patronized Marche Turenne and Amblers, Manotick Ont. as preferred suppliers.

Quality of product was the primary reason cited for buying from southern suppliers in all cases. With the businesses, price and volume supply ranked second as reasons, but quality remained as the prime concern.

costs for transporting food North were ascertained to be a standard $1.69 per kg. for both business and private parties.

Business purchasers	locally 3.6 %	South 96.4 %
Consumer purchasers	locally 70.6 %	South 29.4 %

Cost as a serious consideration in choice ___45___% yes ___55__% no

The following data was compiled to determine what effect variations in either income or outside controls play on food purchasing habits. Controls were seen as required nutritional value for contracts providing food services to institutions and/or strict budgetary controls in the food service industry e.g. restaurant & hotel ratios of food cost/revenues.

In most cases, given the controls mentioned, we found that the individuals responsible for purchasing produce were given virtually free reign to determine what they purchased. This included, in all but one example, the ability to pick or switch suppliers according to the quality and price factor. All respondents indicated a willingness to modify their habits if a local producer could supply good quality product even at a higher price. The acceptable price increase varied from case to case, but averaged out at 16.3% higher.

The questionnaire asked how various factors influenced buying patterns. These included subsidies, budgetary or dietary controls, standing order purchasers, waste through spoilage and respondent's opinions on higher prices for improved produce quality. The following table details the responses.

Respondents who benefit through food subsidies	----19. 2___%
Respondents who purchase with controls/guidelines	_____3. 8----
Respondents who purchase with no buying controls	----96.2___%
Respondents willing to alter purchasing patterns in view of seasonal price and quality variations	____96 . 2___%
Respondents purchasing through standing orders	---- 11.5-_-%
Respondents willing to consider standing orders from a local greenhouse operation	____57 . 7___%
Average Spoilage	---- 11.5___%
Respondents willing to pay more for reduced spoilage	_-53.8-_-%
To those 53.8% willing to pay more for reduced spoilage, the average price increase acceptable	___12.7__-%
Respondents willing to pay more for better quality	____76.9__%
To those 76.9% willing to pay more for better quality, the average price increase acceptable	____15 . 6--%
Respondents willing to pay bonus increase for reduced spoilage and better quality	____23. 1__%
Maximum acceptable increase to the 23.1% above	___16.3__%

SUMMARY OF ABOVE:

The consumer is willing to pay an average **of 14.9% more for locally produced greenhouse produce if the quality is better than currently available and spoilage** due to damage in transit (frost and bruising) is reduced.

Factors influencing purchasers choice: (ref: table pg. 7)

Respondents were asked to rate their priorities when purchasing vegetables by the following criteria with #1 as most important in their decision process:

Consistent Quality
Dependable Supply
Higher Prices
Volume Supply
Taste
Appearance

The information gathered was examined to establish how the buyer viewed these factors in deciding where to purchase their produce and what type to buy at any given time.

Factor	Relevant to % of buyers	
Appearance	92%	(24)
Consistent Quality	88%	(23)
Taste	85%	(22)
Dependable Supply	74%	(19)
Higher Prices	54%	(14)
Volume Supply	35%	(9)

The following table should be interpreted horizontally to appreciate it's content. The Total numbers to the right indicate how many respondents considered that factor of any importance while each vertical column represents the number of respondents who placed which significant value to the factor.

It was found that no one placed their highest priority as being higher prices and indeed, this factor was only the 4th priority to half of those who considered it at all.

In each vertical column, we have underlined the greatest response numbers. . e.g. First in priority is Consistent Quality, Second priority ties Quality & Dependable Supply.

An accurate appreciation of the figures requires cumulative totals of each Factor on the horizontal scale with repeated comparisons to the corresponding figures on the vertical.

In this way we can see how as a Primary Concern, # 1 on the horizontal scale, the factors rank as follow:

1. Consistent Quality (11)
2. Dependable Supply (9)
3. Taste (8)
4. Appearance (2)

By extension, we see that while Appearance concerns the most, 24, only 2 of the respondents considered it most important.

NOTE: While the factors **of Taste and Appearance relate to "Quality"** in general, the designation 'Consistent **Quality"** was required to address the Restaurant and Institutional requirement for consistency of acceptable quality. For example, they prefer consistent 'Grade B' produce rather than a fluctuation between **"Grade A"** and "Grade C".

Factor/Importance	1	2	3	4	5	6	Total
Consistent Quality	**11**	**6**	4	2	0	0	23
Dependable supply	9	**6**	2	2	0	0	19
Higher Prices	-0	5	2	**7**	0	0	14
Volume Supply	0	1	1	0	**5**	**2**	9
Taste	8	4	5	2	2	1	22
Appearance	2	4	**10**	**7**	1	0	24

CONCLUSIONS

Consumers, Business & Retailers are all willing to support such an enterprise in spite of a perceived price increase.

All but one support the project as envisaged to assist Northern-based Business.

If the project can produce quality produce with a price increase of 15% above current retail prices, a consumer market is available and eager.

To serve the business and institutional market, a similar price increase appears acceptable but the volume required would have to be met consistently as they cannot split their orders between local and southern suppliers due to the extra time and administrative work required to place seperate, partial orders.

Both retailers interviewed expressed interest in marketing greenhouse produce but one recommended self-marketing to increase project profits.

Consumer respondents indicated a willingness to shop for their vegetables at a seperate location than either the Bay or Arctic Ventures if the quality was better.

COMMERCIAL GREENHOUSE FEASIBILITY STUDY

IQALUIT, NWT

HORTICULTURAL DESIGN AND PRODUCTION SCENARIOS

MARK ROMER
Horticulturalist

Department of Biology
McGill University
1205 Avenue Docteur Penfield
Montreal, Quebec, H3A 1B1
(514) S98-6471

JUNE 1988

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DESCRIPTION AND EVALUATION OF HYDROPONIC GROWING SYSTEMS AVAILABLE FOR COMMERCIAL VEGETABLE PRODUCTION IN CANADA

This section will (1) describe and evaluate the hydroponic growing systems available for vegetable production today; (2) list advantages and disadvantages of each within the context of "arctic production" and (3) select three systems to be compared in the subsequent economic analysis.

1.1 GREENHOUSE VEGETABLE PRODUCTION IN CANADA

The Greenhouse industry in Canada has increased steadily over the past decade and currently, over 4 million square metres of glass and plastic structures exist. The largest proportion of this area is dedicated to the production of flowers (ornamental and bedding plants) and accounts for 85% of total industry dollars. Vegetable production occupies the remaining 15% of the greenhouse market and is predominantly dedicated to tomatoes and cucumbers.

The majority of greenhouses producing vegetables in Canada utilize soil as the plant growing medium. Good quality soil 1S readily available in the primary centres of production (Southern Ontario Q, Southern Quebec) and initial capital expenditures are substantially lower than for hydroponic systems.

The area under hydroponic cultivation in Canada remains small but has increased steadily, particularly in recent years with an influx of Dutch and Danish technology and expertise. During the past five years, a substantial number of commercial hydroponic greenhouses have been built and grower interest is turning towards the new methods of cultivation. In British Columbia, over 90% of the greenhouse industry uses sawdust culture to overcome soil related problems.

Although the majority of Canadian operations are small, family–run units of less than one acre, several larger production houses are now present in Ontario, British Columbia, Alberta and Quebec. A few of these operations will be briefly described later in this section.

1.2 SOIL VERSUS SOILLESS (HYDROPONIC) CULTURE

There are numerous advantages and disadvantages to both soil and soilless growing systems. A few relevant ones are described here.

(1) LACK OF SUITABLE SOILS

The primary incentive for using soil less culture methods in the arctic is the lack of suitable soil resources. Past studies have demonstrated that arctic substrates (i.e. sand, peat and organic sediments) are suitable as growth media for many vegetables providing a regular fertilization program is followed (Romer 1983, 19S7) Unfortunately, large quantities of local substrates would be required to supply a commercial enterprise and these at-e not readily available in most northern locations.

(2) SOIL PREPARATION & STERILIZATION

In order to eliminate soil pests and pathogens, soils must be steam or chemically sterilized between crops. This procedure often requires 2 to 3 weeks and is labour intensive. Labour requirements associated with soil collection? processing and cultivation are also eliminated in hydroponic systems.

(3) WATER

The conservation of water resources in areas of limited supply is of particular relevance in arctic areas. Closed hydroponic systems re-circulate water and nutrients thereby reducing costs Of water delivery, storage, heating, and disposal. Plants grown in hydroponic systems are also subjected to reduced water stress associated with soil systems. One essential requirement limiting the success of hydroponic culture is the availability of water of acceptable and consistent quality.

(4) PLANT NUTRITION

Hydroponics permits improved control of plant nutrition and rapid correction of nutrient imbalances or deficiencies. Systems may be fully automated to ensure reliable nutrition of crops and sampling procedures are simpler. Soil systems do however have a greater buffering capacity and require much less knowledge of nutrient status.

(5) YIELDS

Crop yie lds of 50% to 500X higher have been documen ted for hydroponic versus soil based systems around the wo r id.

(.5) ENERGY REQU IREMENTS

Recent stud i es have demonstrated reduced energy consump t i on and heating costs associated with hydroponic growin S system=. In arctic regions, the largest component of annual operating costs will arise from lighting requirements and the design of all commercial efforts should endeavor to maximize available sunlight for craps.

(7) PESTS & PATHOGENS

Perhaps the most serious drawback to closed (re-circulating) soil less systems is the rapid spread of pests and pathogens to all plants sharing a common nutrient tank. Since most of the serious diseases are soil-borne, and since the snow-free period in arctic regions is relatively short, this problem may be reasonably well controlled with sound sanitary practices.

(8) CAPITAL COSTS

Capital costs per acre are substantially higher for soil less systems but annual operating costs at-e lower.

1.3 . WATER CULTURE SYSTEMS

Water culture is the truest form of hydroponics where plants are suspended in nutrient enriched water without the benefit of any support medium for their root systems.

1.3.1 NUTRIENT FILM TECHNIQUE

Nutrient **Film** Technique, or NFT for **short, is currently the most popular of water based growing systems.** In this form of hydroponics, plant roots are suspended in a trough or channel through which nutrient solution is continuously circulated. Channels are sloped on a gradient of 1:75 ft to ensure even flow of nutrient solution. Plants develop a thick root mat which grows partly above and partly below the nutrient stream ensuring adequate supplies of water, nutrients and oxygen.

The nutrient solution circulates within a closed system between a catchment tank and the growing channels. Nutrient concentrations and pH are continuously monitored by **a system of** automated controllers and dosing pumps (illustrated in Section 4)

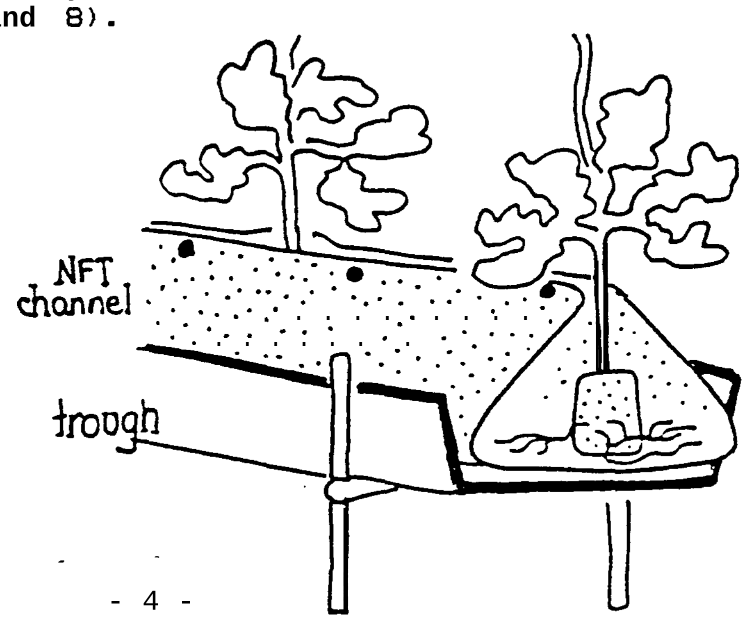
Although many designs have been tested, two principal systems are currently being favoured by commercial growers in North America.

(A) LARGE PLANTS REQUIRING SUPPORT
(TOMATO, CUCUMBER)

In **this system, plant roots are** grown **within polyethylene gullies** located either *on* (a) sloped greenhouse floors or (b) upon raised benches (see illustration below). Plant shoots are **supported above the gullies by means of wires and trellis networks (see Figures 7 and 8).**

FIGURE 1

Typical NFT system for the production of tomato and cucumber



Perhaps the most widely publicized greenhouse operation in Canada is Philip Sprung's SESE (Sprung Environmental Space Enclosure) located in Calgary, Alberta. This 8.5 acre NFT greenhouse boasted production levels of 18.5 cucumbers/ft2/year; more than 3.2 times the Canadian greenhouse average. Tomatoes were similarly productive averaging 28,000 tomatoes/day.

Plants were grown in double rows along a network of raised gutters. Conventional NFT plastic (black interior/white exterior) was utilized and nutrient solution was monitored by a computer injection system. Production levels wets maintained high with the help of carbon-dioxide enrichment and a specially engineered fabric (protected by 18 patents) which is reported to increase light levels significantly inside the greenhouse= Continuous production was ensured through the successive planting of crops at 3 month intervals and a rigid protocol of sanitary practices reduced the occurrence of pathogen problems.

Although the validity of Mr. Sprung's "light-enhancing" covering and production figures have been viewed with skepticism by the Canadian greenhouse establishment, the effectiveness of the NFT growing system was well demonstrated.

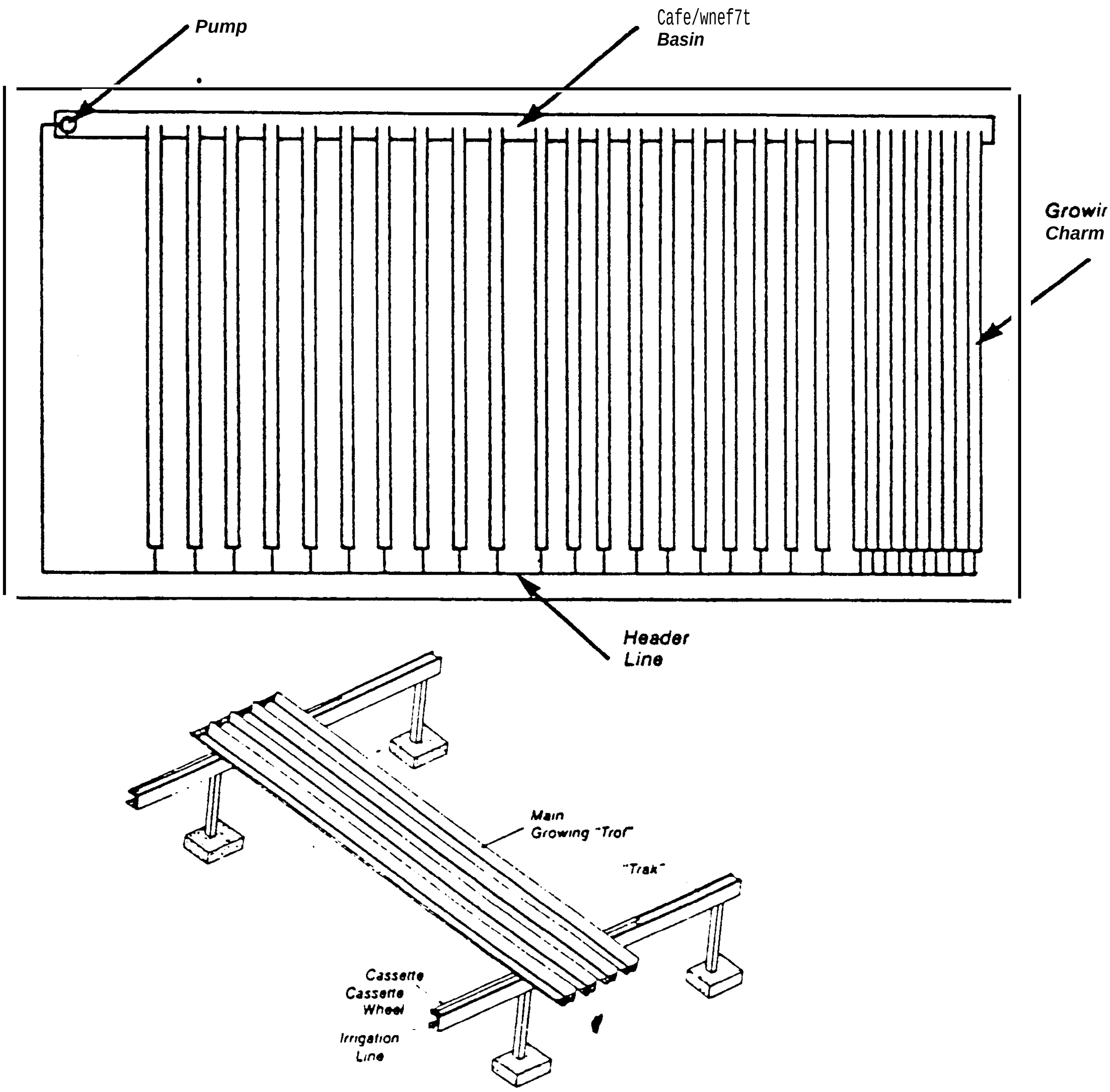
Research at Laval University's Center for Sheltered Crop Specialization has also demonstrated high yields of cucumbers under NFT cultivation. Using supplementary lighting, and CO2 enrichment, Dr. Andre Gosselin has been able to produce 8 cucumbers/ft2/year and maintain production over a 12 month period. This thanks primarily to the availability of inexpensive hydro-electric power to maintain light levels during the winter months.

Ontario tomato growers utilizing NFT systems have reported yields of between 15 and 22 pounds per plant over spring and fall planting=. These yields average I@> tons/acre and represent good yields compared to soil culture.

SMALL SELF-SUPPORTING PLANTS
(LETTUCE, SPINACH, CHINESE CABBAGE, HERBS)

The NFT production of lettuce and other small self-supporting vegetables has gained Popularity in recent years with new growers and currently several Canadian greenhouses are actively involved in "continuous-cropping" systems. These "moveable" growing bench systems utilize rigid rectangular pro-file PVC channels supported by a manual conveyor top bench as illustrated on the following page.

FIGURE 2 Continuaus cropping NFT culture system far the production of small vegetables and herbs.



The NFT channels at-e fitted with removable covers into which are drilled holes for seedlings. Plant roots sit in the channel and are bathed by t-e-circulating nutrient solution fed from a header tube and drained at the opposite end of the channel. As with tomato and cucumber troughs, the channels used for lettuce must be graded to a 1:75 slope far proper flow of solution.

Channels are planted out with seedlings at one enc of the greenhouse and are harvested from 4 to 8 weeks later at the opposite end of the greenhouse. The entire width of the greenhouse is covered with channels leaving only the ends for aisle/walkway. Seedlings are started out at high density spacings and gradually spread apart as plants increase in size. This permits 20% - 30% greater production over available area than conventional growing systems. Spacing is varied over the production period using channel spacers of varied widths.

A number of commercial channels are available to Canadian growers. Suppliers include Canadian Hydrogardens Ltd of Ancaster, Ontario; Peter Zwart and Associates of Grimsby, Ontario (REHAU gutters) : and Hydro-Gardens of Colorado Springs, CO (Nutrient Flow System)

Living Lettuce, a greenhouse operation developed and aperated by Mr. Helmut Julinot near Toronto, Ontario, h-as successfully demonstrated the possibilities of year--round NFT lettuce production. The operation produces head lettuce of the Dutch Butterhead variety grown from seeds imported from Holland as well as looseleaf varieties “Grand Rapids” more commonly known to North American markets.

Plants are harvested, packaged and shipped to markets with roots intact. This method increases the freshness and storage life of the product with resulting reduction in spoilage. Unlike mast greenhouse lettuce producers, Julinot has succeeded in producing his lettuce without the application of any pesticides or fungicides. This, as a result of sterile growing houses and the absence of soil in ail parts of the system. Three 300 foot greenhouses produce an estimated 350,000 heads of lettuce annually which wholesale for $1.10 (1982) directly to the users. Plant supply is continuous with new seedlings being planted as mature plants are harvested.

Another example is Hydroserre Inc., one of several new hydroponic aerations to open within the last year near Mirabel, Quebec. Hydroserre greenhouses cover 3 hectares of land and are expected to be the province’s largest greenhouse producer of lettuce before the end of 1988. As with the case of Living Lettuce, plants are grown in an NFT continuous production system. Production during the winter months will be improved through the use of HID (High Pressure Sodium) lights and throughout the year by the maintenance of elevated CO2 levels.

ADVANTAGES & DISADVANTAGES OF NFT SYSTEMS

The primary advantage of using NFT cropping systems in the arctic is the elimination of costly importation of soils/growing media on an annual basis. In addition, the amount of time and labour required for cleanup and sterilization between crops is greatly reduced leaving more time for crop production. The capital costs of NFT systems are however, higher than other systems. These may be partially offset by reduced heating costs of up to 30% possible if the nutrient solution is warmed and air temperature lowered.

The primary disadvantages of NFT cropping systems are the rapid spread of disease through the crop and the tendency towards nutrient imbalances in the circulating solution. Greater attention must be paid to greenhouse sanitation and frequent analysis of solution and plant tissue samples is required. Because NFT systems have no buffering capacity when the water supply is stopped, it is essential that backup pumps and generators be on hand to keep the solution circulating in the event of primary pump failure.

1.3.2 TANK CULTURE

In tank culture systems, plants are suspended by a thin layer of styrofoam over a tank or "pool" of nutrient solution. The nutrient solution is circulated at fixed intervals to provide aeration for roots. This system has greater structural requirements associated with the construction of tanks and larger quantities of water are involved in production.

Tank culture is not actively used in North America although Harnois Industries of St-Thomas, Quebec, is currently developing a unit for the production of lettuce. Since very little first hand knowledge is available about the specifics of growing with this system, it will not be considered for use in an arctic greenhouse at this time.

1.4 AGGREGATE CULTURE SYSTEMS

In this form of hydroponic culture, inert, solid aggregates (peat, sand, rockwool, gravel among others) are used as a rooting medium which function primarily to anchor the plant roots while also providing oxygen and water. The similarity of aggregate systems lie in the controlled distribution of nutrients in a soluble fot-tin through a network of tubes and feeder lines.

Two principal forms of nutrient application are utilized:

1. CLOSED SYSTEMS where the nutrient solution is recycled with additional nutrients and makeup water added on a regular basis.

2. OPEN SYSTEMS whet-e the nutrient solution is net recycled. This system consumes a larger quantity of water and nutrients but has several distinct advantages including reduced transmission of pathogens and reduced salt accumulation in growing substrates..

An open system is generally recommended where adequate supplies of water are available. In Iqaluit, the following considerations tend to favour the use of closed systems for all forms of plant culture.

- Water supplies are limited, costly and should be conserved as much as possible.

- Irrigation water and nutrient solutions must be heated to 25 C at considerable energy expense. The recycling of water reduces heating requirements substantially.

- Disposal of water is by truck not sewer thus necessitating the construction of water storage facilities and additional capital/operational costs not incurred by southern growers.

One of the principal disadvantages of a closed system for aggregate culture is a resulting accumulation of nutrient salts which are often found to precipitate in the substrate. If a closed system is selected, special modifications are required in the nutrient supply system, more frequent analysis of solutions and periodic flushing (leeching of salts) of the medium is recommended.

1.4.1 PEAT BAG CULTURE

Peat bag culture is probably the most widely used system for hydroponic vegetable production in Eastern Canada. In this form of culture, black or white polyethylene bags are used as containers instead of pots or troughs. The bags are filled with a wide range of growing media. Currently, the most popular mix utilized in Ontario greenhouses are peat-lite mixes (combinations of sphagnum peat moss and several other inert materials such as vermiculite, perlite, turface or pumice). These mixtures are ideal since they have good water and nutrient holding capabilities and yet remain porous enough to provide good aeration of the root zone. Some of the other possible combinations that have been utilized include:

- 40% peat moss; 40% vermiculite and 20% sand or perlite
- 40% peat-lite with 60% sawdust, sand or rice hulls
- 100% peat-lite mixtures such as Pro-Mix BX
- 50% peat moss with coarse aged sawdust
- coarse washed sand
- 50% sand and 50% vermiculite
- rock wool and peat-lite mixes

It is conceivable that some of the local substrates available around Iqaluit may be suitable for use in bag culture. Local sand and peat have been successfully used by researchers in Rankin Inlet (Romer 1983) and Pond Inlet (Romer 1987) to produce a wide range of vegetables. The majority of substrates available in arctic areas have little to no nutrient content and would need to be supplied with a constant fertilization program similar to other peat bag media. It may be wise to initiate production in the pilot Greenhouse with a proven mix of media and gradually experiment with local substrates.

Bags are replaced entirely after one to four crops. If bags are used for more than one crop, the mixture may need to be pasteurized. In the arctic, the lower incidence of bacterial and fungal spores should greatly reduce the incidence of pathogen problems and reduce the need for pasteurization. The use of bags reduces labour requirements associated with greenhouse cleanup.

Nutrients and water are supplied to each bag at preset intervals through a network of feeder lines and drip emitters. Nutrient concentration and pH is monitored and adjusted by a series of controllers and dosing pumps (injectors) which can be fully automated. Although best suited for tomatoes, cucumbers and lettuce, peat culture has been used to produce eggplant, peppers, zucchini and strawberries.

1.4.2 ROCKWOOL CULTURE

During the past few years, a substantial number of Canadian vegetable and flower growers have begun using an inert substrate of European origin known as rockwool. Rockwool is manufactured from diabase, a volcanic t-ml:: which is spun, as a molten material, into fibres and subsequently cooled and compressed into slabs of given density and shape.

Rockwool is completely sterile and eliminates the need of pasteurization required of soils and peat mixtures. Its large pore volume provides excellent water holding capacity (providing plants with some buffer during feeding pump failure). It lends itself well to automation in irrigation and nutrient delivery systems. The expected lifetime of the slabs is from 1 to 4 years and although pasteurization is recommended between crops, many growers have successfully produced several crops without it.

Rockwool slabs measuring 20 x 90 x 7.5 cm are used for production of cucumber, melon, eggplant and squash. Smaller slabs measuring 15 x 90 x 7.5 cm are used for tomato and pepper production. In addition to these growing slabs, smaller "grow blocks" are used for growing young transplants prior to being set out on slabs. These blocks are also used for the hydroponic cultivation of lettuce and herbs.

Most growers using the rockwool system in Southern Ontario are producing flowers. Tomatoes and cucumbers are the two most popular vegetables grown in this medium. Since rockwool is a relatively new system in Canada, considerable research is being conducted on technical aspects of crop nutrition and selection of suitable varieties.

ADVANTAGES & DISADVANTAGES OF ROCKWOOL CULTURE

The primary advantage of rockwool culture is it's simplicity as a growing medium. Light, sterile and ready to use slabs require no preparation and are easily disposed of at the completion of growing. All advantages listed for peat bag culture are applicable to this system. Rockwool may be easily adapted to a raised trough system or laid directly on a graded floor.

The primary disadvantage of this form of substrate for arctic culture is, as for any imported media, the high cost of freight between the supplier and the northern grower. If, however, media must be imported, rockwool may be a lighter and less expensive alternative to peat mixes. As with peat bag culture, closed systems are prone to nutrient imbalance, salt accumulation in the medium and higher occurrence of diseases than in open systems.

1.4.3 SAWDUST CULTURE

Sawdust is widely used in Western Canada where forest industries are numerous. The culture of plants is very similar to that of peat. Since the availability of this resource is limited to arctic growers, it will not be considered for this report.

1.4.4 SAND OR GRAVEL CULTURE

Sand and gravel culture are the two most widely used methods of hydroponic growing in the world today. The largest use of these two methods is in the Southwestern States (Arizona 26 acres) and the Middle East (Abu Dhabi 20 acres). The setup and culture methods used for these two media are similar and will be discussed together.

In this form of culture, the medium is placed in large beds or directly on the surface of the floor. Beds are 12 to 14 inches in depth and of varied widths. Two methods of nutrient supply are available. An open, trickle irrigation system is most commonly used for sand culture while gravel systems use a closed recycling sub-irrigation technique to provide water and nutrients to the plants. Water is pumped into the bed from below and allowed to flood the bed completely for several minutes before draining back to the storage tank. This system requires large storage tanks and is impractical in a small greenhouse situation.

ADVANTAGES & DISADVANTAGES OF SAND & GRAVEL CULTURE

The primary advantage of these systems is that, once installed, no replacement of media is necessary". The primary requirement for these systems is good quality sand (concrete river wash 0.6-2.0 mm) or gravel (crushed granite) having good drainage but still able to retain moisture. These may not be available in the north and are far too costly to import. The construction of the growing beds, reservoirs and support systems are costlier than far other aggregate systems. The medium must be sterilized with steam or chemicals between crops and the removal of root material is difficult and time consuming. Salt buildup is common to both media and routine flushing is required.

Perhaps the largest disadvantage to these systems in the arctic context is the difficulty of maintaining the temperature of the medium. Heating pipes installed directly in the medium have not proven very successful. Also, few if any Canadian greenhouses utilize these growing systems and support information is minimal.

1.S SELECTION OF GROWING SYSTEMS FOR ECONOMIC EVALUATION

Based on the advantages and disadvantages of the different growing systems described in this section, the three systems which, in the opinion of the author, are likely to be best suited for arctic culture are:

NFT CULTURE
PEAT BAG CULTURE
ROCKWOOL CULTURE

The primary reasons for selecting these systems is that they require similar setup and support facilities and are to some degree interchangeable (In the proposed designs which follow, NFT may be converted to peat bag or rockwool or vice-vet-s=).

In the following sections. ail three growing systems will be evaluated and information will be supplied on technical aspects of design as well as suppliers and related economic=. For peat bag and rockwool culture, both closed and open systems will be evaluated in terms of costs and practicality.

SECTION 2

INTERPRETATION OF THE MARKET SURVEY AND SELECTION OF SUITABLE VEGETABLES FOR INITIAL PRODUCTION

The second section of this report will review the Greenhouse Market Survey " Market Study far a Commercial Greenhouse in Iqaluit, NWT " Dean Hay , March 1988 and examine other factors relevant to the **selection of suitable vegetable varieties for northern greenhouse production.**

The selection of suitable greenhouse vegetables will **be made** using the fallowing criteria :

[A] ECONOMIC FEASIBILITY

Economic Attractiveness
Weekly Consumption
Popularity
Product Supply

[B] HORTICULTURAL FEASIBILITY

Suitability for Greenhouse Culture
Suitability for Arctic Culture
Technical Support Facilities

The horticultural and economic considerations will receive equal weighting in the final selection process.

2.1 ECONOMIC FEASIBILITY

Using the market survey, the top ten vegetables imported to Iqaluit may be ranked according to (1) Consumption and (2) Total Market Value.

TABLE 1 Weekly consumption and market value of fresh vegetables imported to Iqaluit (January 1985)

VEGETABLE TYPE	WEEKLY CONSUMPTION	RATING	WEEKLY TOTAL MARKET VALUE	RATING
POTATOES	3245 lb	1	3,887.51	1
LETTUCE (#)	711 head	2	2,528.16	2
TOMATOES	649 lb	3	1,388.86	3
CARROTS	575 lb	4	822.25	4
ONIONS	525 lb	5	803.25	5
CUCUMBERS (*)	405 lb	6	779.57	6
CAULIFLOWER	111 head	10	710.40	7
FROZEN PEAS	260 lb	9	707.20	8
CELERY	339 stalks	8	664.44	9
CABBAGE	365 lb	7	596.75	10

(#) Total of Iceberg and Romaine Lettuces
(*) Total of Regular and English Cucumbers

From Table 1, it is apparent that potatoes, lettuce and tomatoes are the primary vegetables consumed in Iqaluit. The total weekly market value of these three vegetables is $ 7,804.53, or 53 % of all vegetables surveyed.

Traditionally, greenhouse cultivation is far costlier than field culture, even when importation costs are considered. Greenhouse culture is more labour intensive and production is far less mechanized than is possible in the field. Capital and overhead costs, particularly in northern climates, greatly increase production costs. For economic reasons, few of the crops listed in Table 1 are ever grown in a greenhouse.

Table 2 illustrates the potential return for the major vegetables consumed in Iqaluit assuming greenhouse culture is possible. The production figures quoted for the root crops such as potato, onion and carrot are field estimates plus 20% (assuming increased yields under greenhouse culture).

TABLE 2 Potential returns ($/week/acre) for the 10 top vegetables consumed in Iqaluit assuming culture in greenhouses is. possible.

VEGETABLE TYPE	PRODUCTION PERIOD Weeks/Crop	YIELD /acre	VALUE $/lb	POTENTIAL RETURN $/wk/acre
POTATOES	20	16.000 lb	1.20	960
LETTUCE Leaf	52	220,000 hd	3.86 ea	16,330
TOMATOES	52	200,000 lb	2.14	8,230
CARROTS	10	35,000 lb	1.43	5,005
ONIONS	20	28,000 lb	1.53	2,142
CUCUMBERS				
English	52	220,000 cuc	4.08	17,261
Regular	52	220,000 cuc	1.40	5,923
CAULIFLOWER	14	10,000 hds	6.40 ea	4,571
FROZEN PEAS	10	2,000 lb	2.72	544
CELERY	15	20,000 lb	1.96	2,613
CABBAGE	16	13,000 lb	1.55	1,260

Based on the figures estimated above, it is apparent that lettuce, English cucumber and tomato are potentially very attractive as craps for Greenhouse production.

PRODUCT SUPPLY

One of the essential requirements of the northern market is a constant and reliable supply of produce. The major vegetables consumed in Iqaluit may be divided intotwo groups according to the nature of their harvest:

(A) CONTINUOUS HARVEST : Fruit -producing crops such as tomat O, cucumber and pepper at-e characterized by multiple fruits produced and harvested over several months of time. This type of vegetable is desirable far the northern greenhouse as it ensures a continuous supply of produce over a long cultivation period.

(B) SINGLE HARVEST : Most crops tall under this category. Plants grow for a period of time and are harvested destructively at the end of the cultivation period. In order to ensure a steady supply of produce it is necessary to continuously initiate cultivation of new plants where previous ones have been harvested. The cultivation of such crops under greenhouse conditions would increase labour requirements and costs associated with seeding,trans-planting and cleanup between crops.

POPULARITY

According to the survey, respondents were unanimous in the choice of fresh vegetables they would like to see made locally available. Of the major economic crops listed in Table 1, Tomatoes, Lettuce and Cucumbers were seen as the most desirable choices. Of primary concern to the survey respondents was the availability of vegetables of "Consistent Quality".

This relates directly to the current quality of produce available to local consumers in most northern towns. Typically, storage craps such as potatoes, carrots, and onions have the largest consumption because they are easily transported, have a long shelf life and are of consistent quality. In contrast, perishable produce such as tomatoes, lettuce and salad greens tend to have a very short shelf life and frequently suffer damage during transport. These factors result in vegetables of greatly varied quality.

The selection of vegetables should therefore attempt to fill the current need for better quality produce of the more perishable varieties. The selection of popular varieties will also guarantee a steady market demand for local growers.

2.2 HORTICULTURAL FEASIBILITY

Theoretically, most vegetables can be successfully grown in greenhouses. Greenhouse vegetables produce greater yields per acre over a shorter period of time than comparable field crops. Despite these features, only a limited number of vegetables are currently produced in green houses due to the far greater production and capital costs involved. Of the major vegetables consumed in Iqaluit, the following ones are activ , being grown under glass in Canada :

	NUMBER OF GREENHOUSES	PERCENT OF TOTAL	VALUE OF CROP
1. TOMATO	387	52%	$ 30 Million
2. CUCUMBER	281	38%	$ 23 Million
3. LETTUCE	} 70	10%	
4. GREEN PEPPER			
5. SPINACH			
6. HERBS AND OTHER			

Statistics Canada 1987

Since the greenhouse culture of any vegetable in the north will be to some extent experimental, the degree of information and support facilities available to the grower will be essential for successful operation. It is therefore recommended to select vegetable varieties and cultivation methods which are most conventional and currently being carried out in Can da. At the present time, the largest number of acres under glass is de voted to four vegetable crops:

1. TOMATO : 8.5 Million ft2 (Ontario)
2. CUCUMBER : 5.8 Million ft2 (Ontario)
3. LETTUCE : No figures available
4. PEPPERS : No figures available

The northern grower may, through consultation with other growers in the south, benefit from time-tried technology and years of experience. In addition, a large number of government and commercial enterprises exist to provide horticultural support to growers. As one may expect, the most information is available for the cultivation of tomato and cucumber as these are the leading crops produced in the country today. Both European (seedless) and American varieties of cucumber can be produced under hydroponic conditions as can over half a dozen varieties of tomato.

Lettuce plants are well suited to hydroponic culture in Canada by virtue of their small size, rapid growing cycle, low temperature and lighting requirements. A wide range of automated, continuous–production growing systems have been developed and tested around the world. Despite these features, total production of greenhouse lettuce remain= small at the present time as most growers prefer the more profitable returns of tomato and cucumber cultivation.

Despite the SUCCeSSfUl operation of these and other lettuce greenhouses. the market for leaf lettuce is limited in Canada.. An estimated 90% of Canadian lettuce production (primarily southern Ontario} is exported to the United States where the demand is high. Ironically, Canadians prefer head lettuce ("Iceberg") and import tons from the Southern States annually. At the present time, head lettuce cannot be grown in totally enclosed greenhouses due to a genetic problem and reduced light levels. Research in Holland has produced a small, loose-headed variety of lettuce ("Crystello") out at present it is not of marketable quality.

Although head lettuce cannot be considered for production in a northern greenhouse, it is this author's belief that a higher quality, reasonably priced leaf lettuce can compete in the northern marketplace. As with many imported products, increased utilization will crime with increased exposure and trial.

SUITABILITY FOR ARCTIC PRODUCTION

The three major factors influencing greenhouse cultivation in arctic regions are cold temperatures, irregular light levels and lack of suitable soil substrates.

(1) SOIL

The lack of suitable substrates in tundra regions presents the greatest obstacle to conventional production of any crap. The selection of vegetables must therefore be made an the basis of the plants ability to grow in

[A] small quantities of imported soil, or
[B] in soil less culture media such as rockwool, peat, sand or water.

The soilless culture of tomato, cucumber, lettuce, and peppers is well developed and actively pursued in greenhouses across Canada. Unfortunately, all root crops such as potato, carrot and onion require large quantities of soil and are less , adaptable to arctic culture. Some success has been obtained with the culture of potatoes in peat mixtures.

(2) COLD TEMPERATURES

Although greenhouse temperatures may be maintained at any desired level, cool weatner craps (Potato, Lettuce, Onion, Carrot, Cauliflower, Cabbage, Broccoli) should be more resistant to temperature changes and produce more favourably in ail seasons than warm weather varieties. The possibility of large scale outdoor or cold frame production of these popular vegetables during the arctic summer should be considered as a future expansion option to any greennouse operation.

(3) LIGHTING

The lighting conditions in arctic regions are also a cause for concern in northern horticulture. In summer, the extended photoperiod may unfavourably influence flower and fruit production in fruiting crops while causing leaf crops to bolt to seed. It may therefore be necessary to include "black out" curtains in any greenhouse to artificially simulate nighttime conditions. In the opinion of Horticulturalist Bill Straver (OMAF, Horticultural Research Institute of Ontario, Vineland), both lettuce and cucumber should be able to grow without adverse effects under tne long day length. Tomato plants may require 4 hours of darkness.

In winter, low light levels require the use of supplemental artificial illumination and vegetables requiring lower light levels for production would be selected. Lettuce in particular favours low growing temperatures (8°- 10°C) and low light levels and may be grown solely under 100% artificial illumination making it an ideal candidate for year-round production in a northern greenhouse. Research at Laval Universities Center for Sheltered Crop Specialization have demonstrated that tomato and cucumber production can also be maintained at reasonably high levels using artificial lighting. The deciding factor with respect to winter production of these crops will therefore be primarily economic.

2.3 RECOMMENDED CROPS :

Based on an assessment of economic and horticultural -feasibility, the following three crops have been chosen as most suitable candidates for preliminary trials in Iqaluit.

1. LETTUCE
2. TOMATO
3. CUCUMBER

The following principal reasons are summarized:

- these crops have high market value and high local consumption but have a limited shelf life and are of inconsistent quality. In contrast, potato, carrot and onion can easily be shipped and stored with negligible loss of quality to consumers.

- the greenhouse culture of these crops is being successfully demonstrated in Canada today.. In contrast greenhouse cultivation of cool weather crops (potato, carrot and onion) would be more experimental and with uncertain results. Root crops would also require large quantities of soil unavailable in Iqaluit.

- these crops have been able to compete successfully with imports on the southern market and can be expected to follow suit in the north.

a wide range of cultivation techniques and growing systems have been successful in producing these three vegetables. Consequently a large number of products and information is readily available from Canadian and American suppliers.

the suitability of these crops to soilless culture is well demonstrated. This feature eliminates the need for soil which is scarce and involves elaborate and costly sterilization procedures between crops.

a large support network is available to growers of these vegetables (government and industry).

these crops have been successfully grown under winter conditions in southern Canada and will likely adapt well to the cool climates of the north.

tomatoes and cucumbers have a long production season with continuous harvest of fruit over 6 to 8 months. This reduces labour costs involved with seeding, transplanting and cleanup between crops. In contrast, most of the ether crops currently consumed have a long growing period with single harvest.

lettuce (leaf) has a rapid maturation and can be produced in just over 7 weeks from seed. When cultivate in NFT hydroponic systems, up to 7 crops may be produced in one year. New designs” in lettuce hydroponic culture permit the continuous cropping of plants in one bed.

although these three crops are recommended for initial trials in an arctic greenhouse, a wide range of other plants may also be produced seasonally under outdoor conditions in cold frames and small quonset-type greenhouses conventionally used for bedding plants in the south. Seasonal production of cabbage, turnips, beets, onions, carrots, broccoli, cauliflower, chinese cabbage, lettuce and spinach would increase variety of local produce and satisfy some of the increased market demand characteristic of this time of year. This possibility should be considered as an “expansion option” for the greenhouse operation and only be considered once the primary growing systems have been successfully established.

PRODUCTION SCENARIOS FOR TOMATO, CUCUMBER AND LETTUCE CROPS IN IQALUIT GREENHOUSE

In this section, a number of scenarios will be presented for the production of tomatoes, cucumbers and lettuce. The following topics are covered:

1. LENGTH OF PRODUCTION SEASON
2. PRODUCT MIX
3. SIZE OF GREENHOUSE
4. TARGET YIELDS FOR EACH CROP
5. GROWING SYSTEM
6. SUMMARY OF SCENARIOS

3.1 LENGTH OF PRODUCTION SEASON

(A) TOMATO AND CUCUMBER

Both crops have a similar cultural design. Seedlings and young transplants require between 10 and 14 weeks of growth before they begin production of harvestable fruit. The subsequent production period may be extended for up to a year providing cultural requirements are satisfied (lighting and fertilization).

Since both these crops require high light levels and warm temperatures for growth, mid-winter production utilizing artificial illumination is likely to be very costly. For this reason, two production periods will be evaluated:

(1) 8 MONTH PRODUCTION
(2) 12 MONTH PRODUCTION

A number of potential production schedules for both options are presented for consideration in Section 5.7 of this report.

(B) LETTUCE

Lettuce plants have relatively low lighting requirements and can be successfully produced under artificial illumination. In addition. growth temperatures for this crop are low and require smaller heating requirement=. Since there is a high demand for this vegetable, and since initial indications suggest 'Winter cultivation is feasible, a 12 month cultivation period is recommended. The time required from seed to harvest extends from o to 10 weeks but an average of 8 weeks per crop will be used for our calculations. This represents an average of 6.5 crops/year.

3.2 SIZE OF GREENHOUSE REQUIRED TO MEET CURRENT MARKET DEMAND

In order to determine the size of greenhouse required to meet current market demand, three sets of statistics are required:

1. Length of growing season
2. Average yields of crops under greenhouse culture
3. Market demand

AVERAGE CROP YIELDS FOR GREENHOUSE VEGETABLES

Table 3 1 lists conservative estimates reported for the hydroponic culture of our 3 selected vegetables in Canada- Estimates for tomato and cucumber plants ate based on totals of spring and fall craps averaged over an 8 month cultivation period. Since little data exists for production over a 12 month period, estimates will be generated from the 8 month data.

TABLE 3 Average yields and recommended growing area per plant for tomato, cucumber and lettuce produced in greenhouses in Canada.

[1] 8 MONTH PRODUCTION SEASON

	YIELD	AREA/PLANT	YIELD/AREA
TOMATO :	20 lbs/plant	5 ft2	4 lbs/ft2
CUCUMBER :	45 cues/plant	9 ft2	5 lbs/ft2

[2] 12 MONTH PRODUCTION SEASON

	YIELD	AREA/PLANT	YIELD/AREA
TOMATO :	32.5 lbs/plant	5 ft2	6.5 lbs/ft2
CUCUMBER :	72 cucs/plant	9 ft2	8.0 lbs/ft2
LETTUCE :	6.5 heads/yr	1 ft2	6.5 heads/ft2

MARKET DEMAND

The market demand for the three selected vegetables is taken from Dean Hay "Market Stud>' for a Commercial Greenhouse in Iqaluit, NWT" March. 1988. For the purposes of this report, both forms of lettuce (Iceberg and Romaine) and cucumber (regular slicing and English seedless) will be combined in the estimated total market demand. It is expected that consumers will favour the fresher, locally produced item regardless of variety.

Weekly Consumption in Iqaluit (Jan 1988)

LETTUCE	:	710 heads/week
TOMATO	:	650 lb/week
CUCUMBER	:	405 lb/week

(from Table 1)

The growing area required to meet current **weekly demand** is calculated as:

$$\frac{\text{LENGTH OF PRODUCTION SEASON} \times \text{MARKET DEMAND}}{\text{YIELD / UNIT AREA}} + \text{SAFETY MARGIN}$$

(*) SAFETY M& RGIN: Tomato and cucumber plants are not characterized by a uniform harvest of fruits week in and week out. Production levels vary with the age of the plant and stage of development. Some loss of fruit may also occur due to disease and during packaging. It is therefore recommended to overproduce to meet target demands. A 15 % margin will be employed for these calculations. Lettuce is more reliable and does not require such a high margin. A 5% margin will be employed.

Using the values estimated above, the following growing areas would be required to meet current demand for these three vegetables in Iqaluit:

TOMATO	5,720 ft2
CUCUMBER	2,850 ft2
LETTUCE	5,960 ft2

A total of 14,530 ft2 of greenhouse complex would be immediately required to meet current demand. This represents a third of an acre of greenhouse area or 30 feet x 485 feet.

3.3 PROPOSED PRODUCT MIX

The following product mix is proposed for the initial greenhouse.

TOMATO . . . . 40% OF TOTAL GROWING AREA
CUCUMBER . . 20% OF TOTAL GROWING AREA
LETTUCE . . . 40% OF TOTAL GROWING AREA

3.4 SIZE OF GREENHOUSE

In consideration of the experimental nature of this project, a starting volume of bet ween 50% and 75% of current market demand should be attempted. Two greenhouse sizes will provide this range of product ion and will be examined for this repor t:

(1) 7,500 ft2
(2! 10, 000 ft2

3.5 TARGET YIELDS ESTIMATED FOR INITIAL PRODUCTION TRIALS IN IQALUIT

Using the information presented in the previous sections, it is now possible to calculate target yields for our selected scenarios. For the purposes of these estimates, it will be assumed that the three selected growing systems are equally productive. Table 4 summarizes production areas, plant numbers and target yields for the Iqaluit greenhouse. These estimates will be used in the following sections to determine cost estimates and design layouts.

TABLE 4 Recommended initial production areas, plant numbers and target yields for the Iqaluit greenhouse.

VEGETABLE	AREA OF CULTIVATION	PLANT NUMBER	TARGET YIELDS WEEKLY	ANNUAL
7,500 ft2 GREENHOUSE				
TOMATO	3,000 ft2	600	375 lbs/wk	12,000 lbs (8 mo) 19,500 lbs (12 mo)
CUCUMBER	1,500 ft2	167	235 lbs/wk	7,500 lbs (8 mo) 12,000 lbs (12 mo)
LETTUCE	3,000 ft2	3000	375 hds/wk	19,500 hds (12 mo)
10,000 ft2 GREENHOUSE				
TOMATO	4,000 ft2	800	500 lbs/wk	16,000 lbs (8 mo) 26,000 lbs (12 mo)
CUCUMBER	2,000 ft2	222	310 lbs/wk	10,000 lbs (8 mo) 16,000 lbs (12 mo)
LETTUCE	4,000 ft2	4000	500 hds/wk	26,000 hds (12 mo)

Having evaluated the target yields for two potential greenhouse sizes, it is now possible to estimate more precisely the proportion of the current market demand which can be satisfied by their production.

% MARKET DEMAND = (WEEKLY PRODUCTION - SAFETY MARGIN (5% LETTUCE) (15% TOM/CUC)) / MARKET DEMAND

CROP	7,500 ft2	10,000 ft2
TOMATO	320/650 = 50%	425/650 = 65%
CUCUMBER	200/405 = 50%	265/405 = 65%
LETTUCE	355/710 = 50%	475/710 = 65%

From this table it follows that the initial production estimates will be able to satisfy between 50 and 65 percent of current market demand.

DESIGN POTENTIAL OF GREENHOUSE

Since all projects should evaluate future expansion potentials, the current project will take into consideration the possible increase of total growing space to 10,000 ft2 per crop. All growing systems will be designed with this target in mind and future expansion will primarily involve structural additions to the existing greenhouses.

In the following table, the author has predicted maximum production capacities should all three crops be increased to a maximum area of 10,000 ft2/crop. (Total of 30,000 ft2 of growing area). An additional "bumper crop" prediction is added to illustrate potential yields of above-average crops and seasons.

Table 5 Potential production of Iqaluit greenhouse assuming expansion of all three crops to 10,000 ft2/crop and 50% increase in crop yields.

CROP	AVERAGE WEEKLY YIELD	PERCENT OF CURRENT DEMAND (%)	HIGH WEEKLY YIELD	PERCENT OF CURRENT DEMAND (%)
TOMATO 10,000 ft2	1,250 lbs	200 %	1,875 lbs	300 %
CUCUMBER 10,000 ft2	1,540 lbs	380 %	2,300 lbs	570 %
LETTUCE 10,000 ft2	1,250 hds	175 %	1,500 hds	210 %

Clearly, the future "design" potential of the Iqaluit greenhouse is substantial. Not only can it be expanded to match the local demand for produce, but it may also surpass local and move to supply regional requirements as well.

3.6 GROWING SYSTEMS

As was outlined in Section 1, three growing systems will be evaluated in this report. These are:

1. NFT CULTURE
2. PEAT BAG CULTURE
3. ROCKWOOL CULTURE

3.7 SUMMARY OF SCENARIOS FOR ECONOMIC EVALUATION

The fallowing summary of the scenario options is presented for use in the subsequent sections:

SIZE OF GREENHOUSE	[A] 7,500 ft2 GREENHOUSE	[B] 10,000 ft2 GREENHOUSE	
GROWING SYSTEM	[A] NFT CULTURE	[B] PEAT BAG CULTURE	[C] ROCKWOOL CULTURE
NUTRIENT RECOVERY	[A] OFEN SYSTEM	[B] CLOSED SYSTEM	
GROWING SEASON	[A] 8 MONTHS	[B] 12 MONTHS	
CROP	[A] TOMATO	[B] CUCUMBER	[C] LETTUCE

TECHNICAL INFORMATION RELATED TO THE GROWING AND LIGHTING SYSTEMS

This section will present additional technical information related to composition and layout of the three growing systems proposed in Section 1.5. The layout of the lighting system and some details on a potential outdoor growing house will also be provided.

4.1 SUPPORT OF GROWING MEDIUM FOR OPEN AND CLOSED SYSTEMS

Generally, most southern greenhouses growing vegetables in peat bag, rockwool and NFT culture place the plants directly on a landscaped greenhouse floor. In the arctic, cold soils underlain with permafrost render this practice impractical. It is therefore recommended that all plants be either (a) raised on a support system (illustrated below) or (b) placed on thick slabs of insulation to shelter the root zone from the cold.

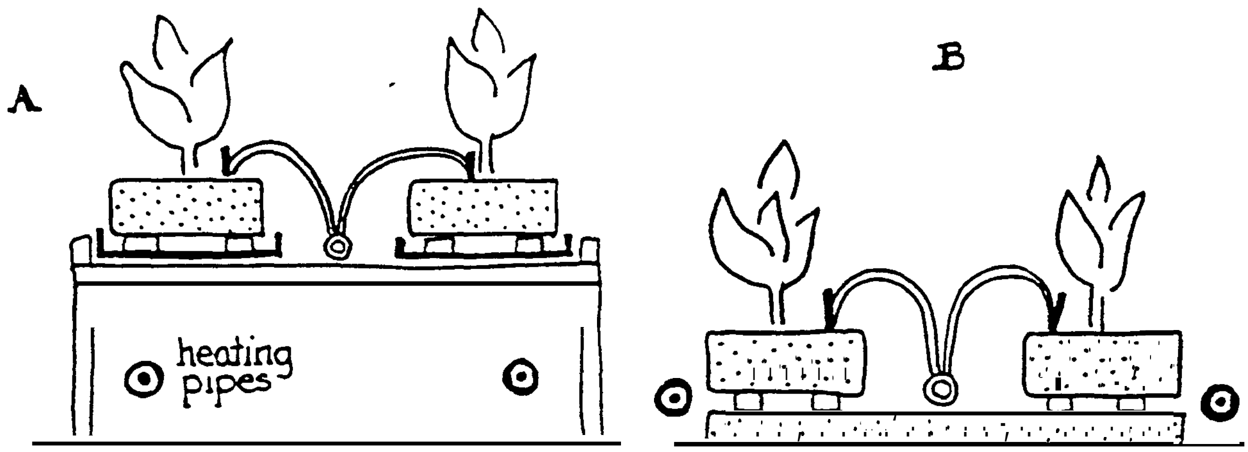


FIGURE 3 Supper t systems convent i ona 11 y ut i 1 i zed for NFT, peat bag and rockwool cu 1 ture.

The raised system (A) offers several advantages. Firstly, heating pipes may be conveniently placed under the benches or troughs producing a warm layer of insulation from the cold floors. This method also contributes to warming the nutrient solution which is re-circulated in the troughs. Secondly, the drainage of solutions out of the system is greatly improved since trough slopes can be more accurately adjusted (proper grading of greenhouse floors is a very difficult task).

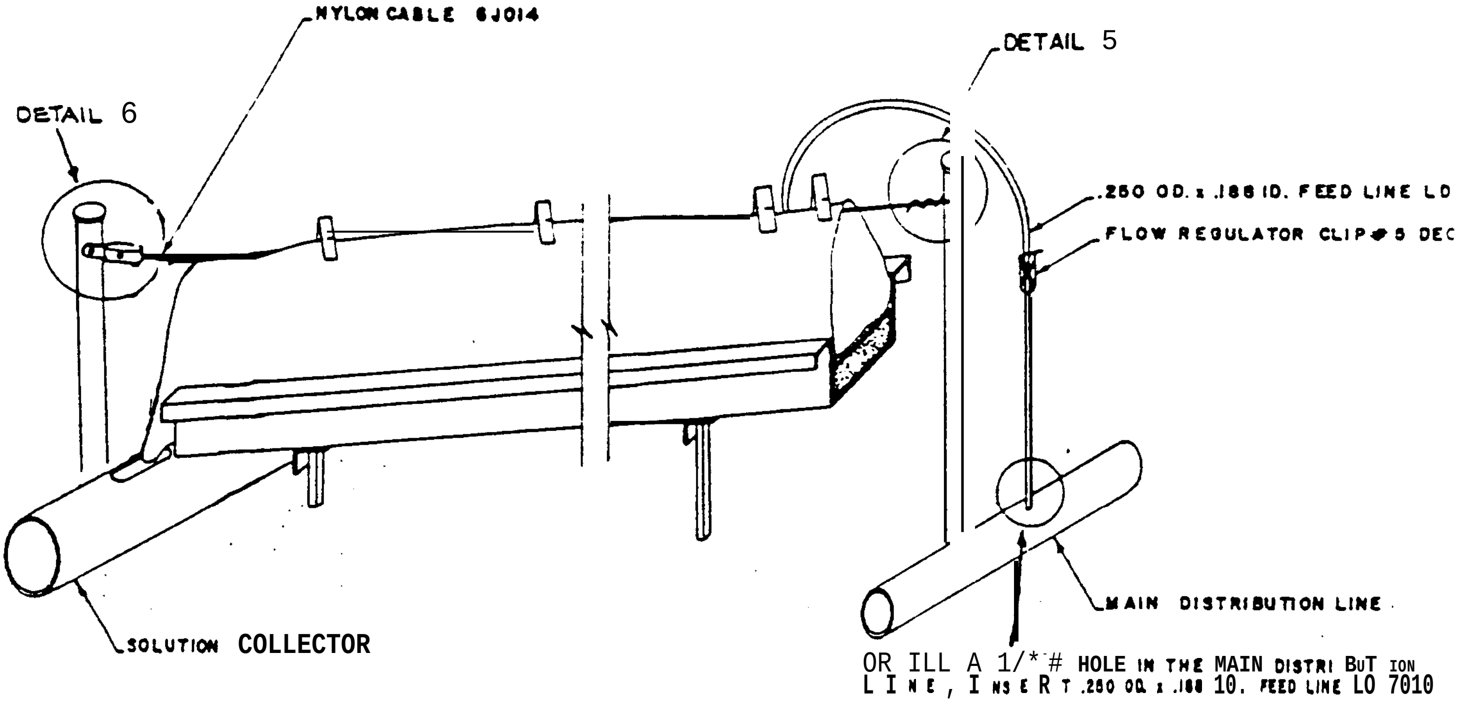
A wide number of materials may be used for troughs, although high density polyethylene is recommended to reduce phytotoxicity of the water/nutrient supply. REKO tm gutters, available from Peter Zwart and Associates are suitable for such put-poses. Troughs may be of any construction if plastic is used to line the inside (as for NFT system described later in this section). A simple design for single and double gutter supports is illustrated in Figure 4. This design is available commercially from Harnois Industries (and quoted for in the economic section) but may also be manufactured from local materials to save shipping costs.

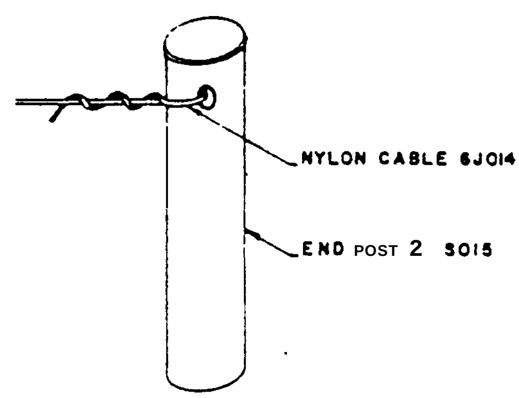
The design of the trough support system is sufficiently flexible to permit use of any of the three growing systems described in section 1 as well as the possibility of future conversing from one system to another.

Careful attention must be paid to grading of the troughs, gutters or floors to ensure a continuous slope of 1:75. This will assure proper flow rates across plant roots in an NFT system and will drain returning water effectively.

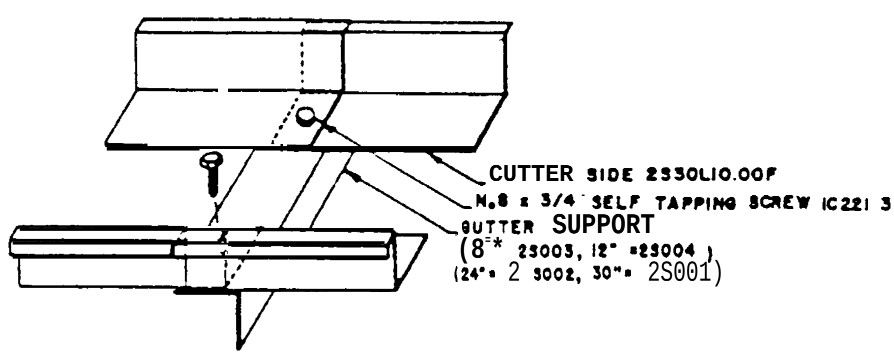
In addition to primary heating pipes under the support system, PVC tubing of small diameter may also be laid down the center of troughs (only under peat bag and rockwool substrates) to improve root zone temperatures. This is of particular importance if substrates are not raised on a support system but are placed directly on a graded greenhouse floor.

FIGURE 4a Structural drawings of NFT support system
(Harnois Ltd. , St Thomas, PQ)

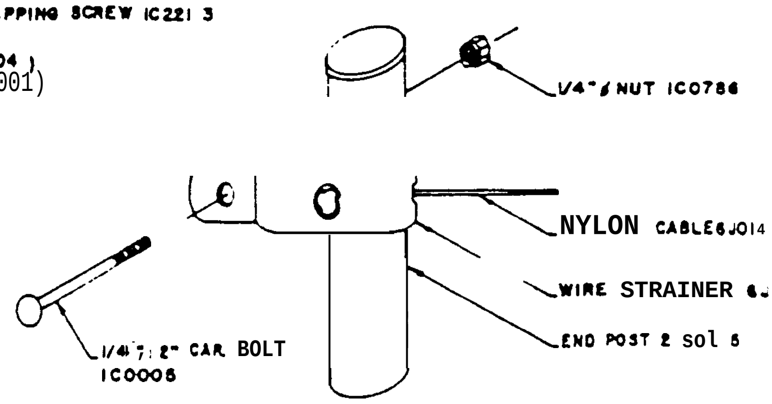




DETAIL 5

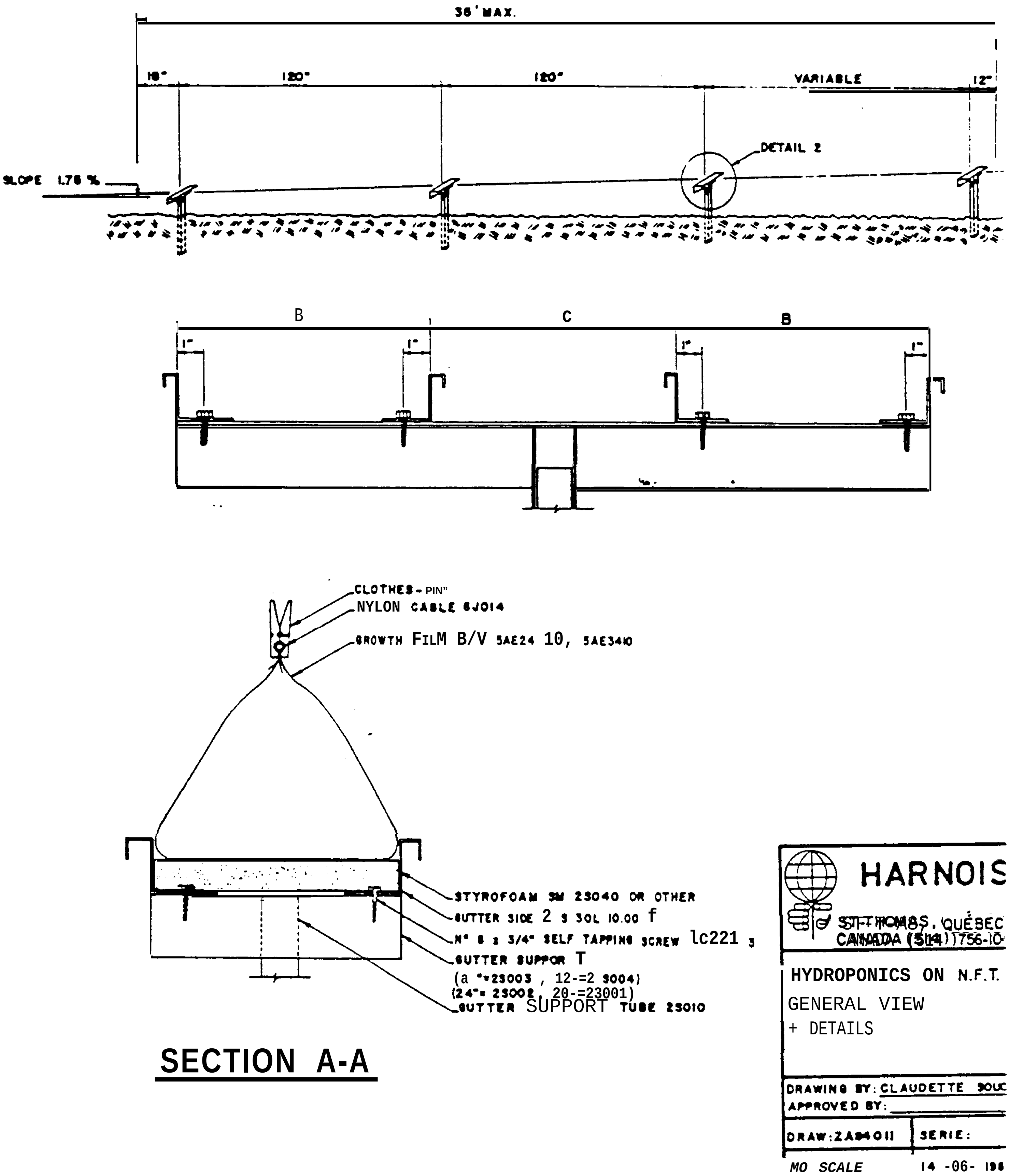


DETAIL 4



DETAIL 6

FIGURE 4b Structural drawings of NFT support system (Harnois Ltd., St Thomas, PQ)



4.2 GROWING MEDIA AND MATERIALS FOR AGGREGATE AND NFT CULTURE

The basic design of NFT and aggregate growing systems has been adequately described in section 1 of this report. This section will simply provide some additional information concerning suppliers of these products.

4.2.1 NFT CULTURE

(A) TOMATOES / CUCUMBERS

The basic design of the standard NFT setup for tomatoes and cucumber-s is illustrated in Figure 4. A wide variety of trough materials are commercially available. For example, Canadian Hydrogardens Ltd of Ancaster, Ontario supply black/white co-extruded fiim "Gro-tube" designed specifically for tomato NFT cropping. The plastic tube is replaced after each crop permitting a rapid cleanup of the greenhouse.

(B) LETTUCE

A number of commercial channels are available for use in a continuous cropping setup. Suppliers include Canadian Hydrogardens Ltd of Ancaster, Ontario; Peter Zwart and Associates of Grimsby, Ontario (REHAU gutters); and Hydro-Gardens of Colorado Springs, CO (Nutrient Flow System)

4. 2.2 PEAT BAG CULTURE

A wide range of potential mixtures is described in section 1. A minimum volume of 10 litres (2.5 US gallons) is recommended per plant for bag culture. Commercial operations tend to use 20 litre bags holding 2 tomato plants or 1 cucumber plant.

Specialized bags are available from Hydro-Gardens Inc. in Colorado made of ultra-violet stabilized EVA plastic which is much stronger than conventional polyethylene. Alternately? some peat mixes are supplied in ready-to-grow bags- For example, Shamrock Industries of Norwich, Ontario markets specially blended “tomato mix” and "Florida cucumber mix" in ready-to-use "Speedel Gro Bags".

4.2.3 ROCKWOOL CULTURE

Rockwool slabs are produced in two sizes:

CUCUMBER ": 20 x 90 x 7.5 cm
TOMATO : 15 x 90 x 7.5 cm

In addition to these growing slabs, smaller "Germination cubes" (tomato and lettuce) and "grow blocks" (cucumber) are used for growing young plants prior to being set out an slabs. Slabs are individually wrapped in two-sided polyethylene (black inside and white outside] to reduce algal growth in the root zone and reflect light to the lower leaves of the crop.

The leading supplier of Rockwool products (trademark GRODAN) is Grodania A/S of Denmark. Grodan products are now readily available to Canadian growers through Aerodynamics of Brooklyn, NY, via distributors in Quebec (Harnois Industries), Ontario (Peter Zwart and Associates) and other provinces. Recently, Plant Products of Bramalea, Ontario announced the arrival of a Canadian produced equivalent (trademark FARGRO). This Product is currently being tested and should be available to growers by late 1983.

4.3 LAYOUT OF GREENHOUSE GROWING AREAS AND PLANT SPACING

The space requirements for cultivating tomato plants range from 4.3 to 5 ft2/plant and for cucumber from 6.5 to 9 ft2/plant. Since the arctic culture of these vegetables is still experimental, the current design will utilize the greater figure in each case. After the prospective grower has completed several crops, plant densities may be increased slightly to increase plant numbers and yields. A 30 foot greenhouse width will be used for the proposed layouts.

Lettuce plants have very small space requirements, often 9 inches square will be sufficient. For the put-poses of this study, a global 12 square inches (1 ft2) will be alloca tea to p roduc t i on.

1. -SPACING BETWEEN ROWS :

TOMATO : Pl ants are grown in double rows separated by gullies 12" wide. Aisles between rows are 36" wide (Fig 7). Gullies are used to lay nutrient solution feed lines. Rows are oriented across the width of the greenhouse and are 24' feet in length (see typical cross-section in Figure 5.

CUCUMBER : Plants are grown in double rows Separated by gullies 12" wide. Aisles between rows are increased to 60" in width (Fig 8). Rows are oriented across the width of the greenhouse and are 24 feet in length (see Fig 5)

LETTUCE : Spacing between channels is adjustable in the proposed "moveable" system and will vary from 1" between channels during the seedling stage to around 12" between channels for mature plants. (See Figure 2 in section 1.3.1). Channels are 24 feet in length and follow the same cross-sectional profile illustrated in Fig. o.

FIGURE 5 Typical greenhouse cross-secti
of tomato of cucumber crops.]
directly on the floor; the mi
is reduced by 18 to 24 inches

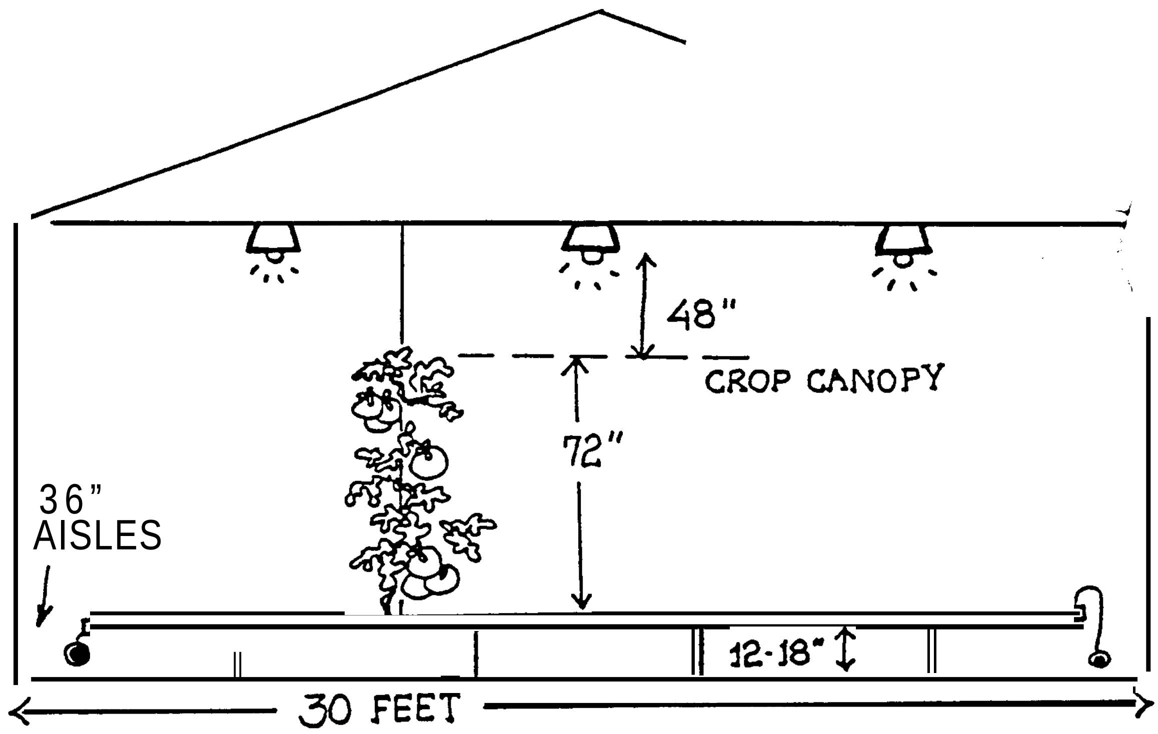
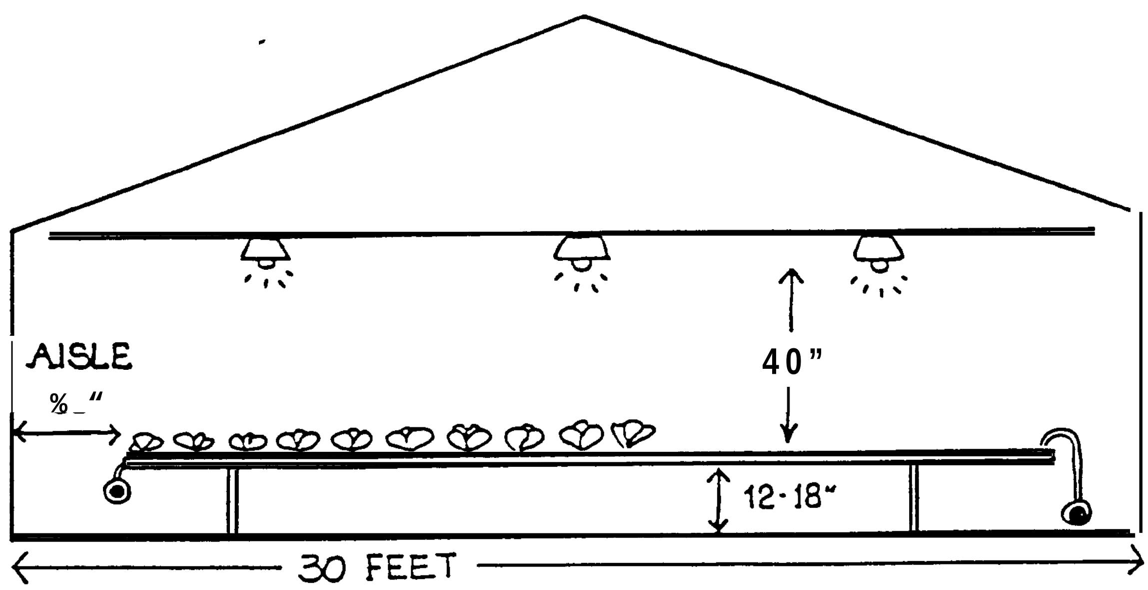


FIGURE 6 Typical greenhouse cross-see t ion far hydropon ic
product ion of lettuce crops -



2. SPACING BETWEEN PLANTS IN ROW : TOMATO : Plants are placed 1 a total of 20 plant Culture. 3 plants a while in peat cult plants may be grow

CUCUMBER : Plants are placed of 13 plants per plants are grown culture, usually bag.

LETTUCE : The spacing between plants in the channel is fixed at 8" center to center allowing a maximum of 36 plants per channel (224').

3. VERTICAL PROFILE OF THE GREENHOUSE

Both tomato and cucumber plants produce vines over 6 feet in height. This feature combined with the need for artificial illumination results in a typically high vertical profile for a greenhouse.

TOMATO : Plants are supported by vertical wires above the growing trough (Figure 7)

CUCUMBER : Plants are supported by wires which form a v pattern above the aisles (Figure 8). This arrangement optimizes the plant's light reception and facilitates inspection and harvest of cucumbers when ripe.

LETTUCE : Lettuce plants have a very low vertical profile and do not require as much headspace as the taller tomato and cucumber crops. For this reason, and in the interest of energy conservation, the vertical profile of the lettuce house may be substantially reduced.

FIGURE 7 Typical row spacing and vertical profile of tomato plants in greenhouse.

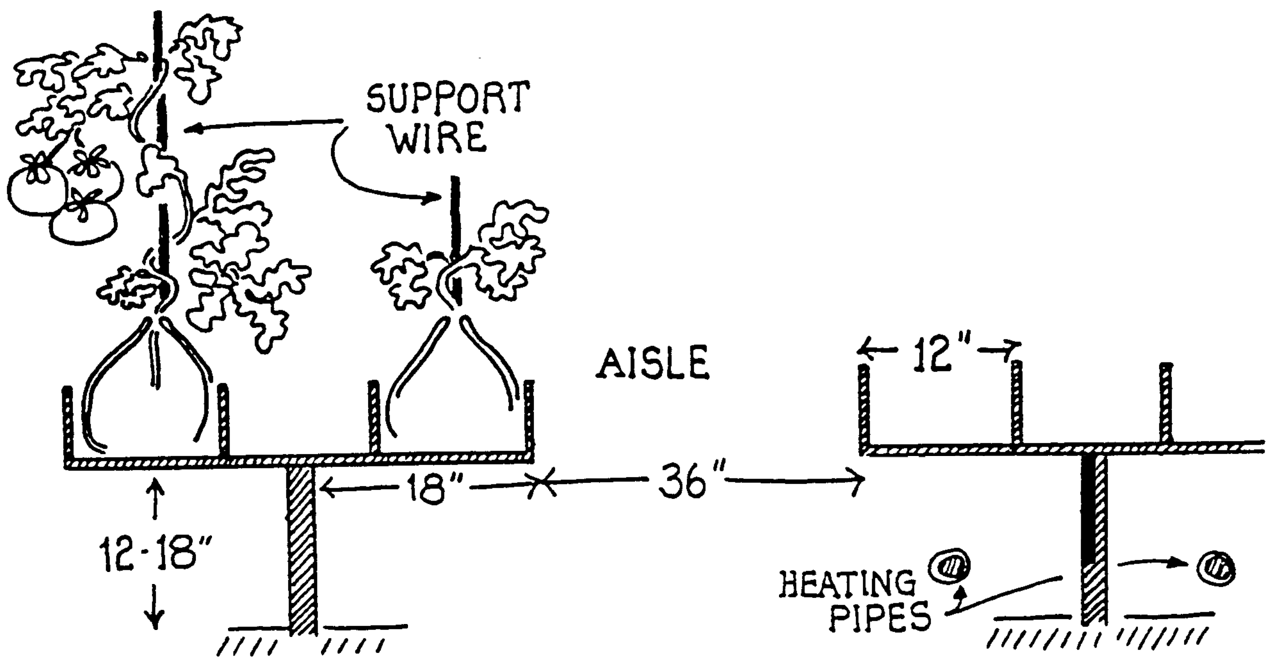
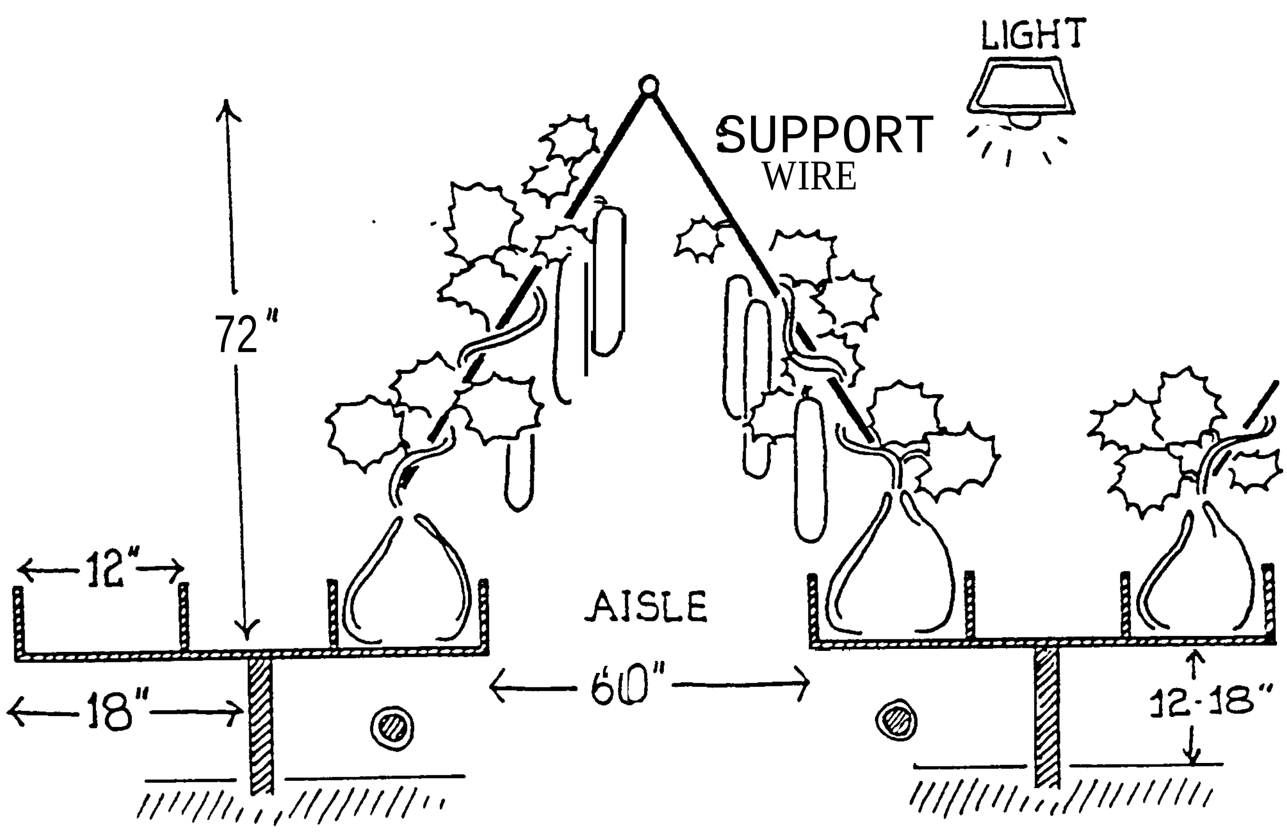


FIGURE 8 Typical row spacing and vertical profile of cucumber plants in greenhouse.



4. **NUMBER OF ROWS PER GREENHOUSE**

The number of rows will vary according to the scale of the greenhouse operation. The following table outlines the number of rows/channels that will be required for a 7,500 ft2, a 10,000 ft2 and future 30,000ft2 green house. All rows are 24 feet in length leaving 3 feet on each side of the greenhouse for walkway.

TABLE 6 Greenhouse dimensions and number of rows required for different size options

GREENHOUSE SIZE :	7,500 ft2	10,000 ft2	30,000 ft2
TOMATO :	3,000 ft2 30 x 100' 30 rows (24')	4,000 ft2 30 x 135' 40 rows (24')	10,000 ft2 30 x 335' 110 rows (24')
CUCUMBER :	1,500 ft2 30 x 50' 13 rows (24')	2,000 ft2 30 x 70' 17 rows (24')	10,000 ft2 30 x 335' 80 rows (24')
LETTUCE :	3,000 ft2 30 x 100' 84 rows (24')	4,000 ft2 30 x 135' 112 rows (24')	10,000 ft2 30 x 335' 280 rows (24')

4.4 IRRIGATION AND NUTRIENT DELIVERY SYSTEMS

Crop nutrition and irrigation are the most important aspects of growing plants hydroponically. Both water and aggregate culture systems chosen for consideration in this project utilize similar equipment and materials and will be described together. A brief summary of operating principle= is provided. Please refer to illustrations of closed and cpen systems in Figures 9, 10, 11, and 12 on the following pages.

In a closed hydroponic system (Fig 9, 11), the nutrient solution is circulated between a catchment tartk or reservoir and the plants in troughs. At the catchment tank (Fig 1), automatic controls and metering pumps (injectors) monitor the water and add liquid fertilizers plus acid according to preset conductivity (EC) and pH limits. The temperature of the solution is maintained using heating coils immersed in the tank. In Iqaluit, it may be *more* economical to instali a water to water heat exchanger to heat the solution tank (instead of electrical immersion heater). Pathogens and algae are controlled by irradiation with ultra-violet light. Aerators are used to increase oxygen content of the solution.

The controller (either computer or timers) pumps water to plants (A) at intermittent cycles (bag and rockwool) or (B) continuously (NFT culture).
In rockwool culture, analyzers located directly in a "test slab" are used to automatically trigger irrigation when slab water volume drops below a predetermined level. Similarly, a trip scale is used in peat bag culture to initiate irrigation.

Water/nutrients are delivered to the plants through a network of main headers, raw headers, leader tubes and drip emitters. Fram the plant, excess nutrient solution drains back through the trough system to the catchment tank.

In an open hydroponic system (Fig 12), all component= are virtually identical except that excess nutrient solution and water being delivered to the plants (peat bag or rockwool) is drained away from the system and not re-used. In the Iqaluit greenhouse, it may be necessary to have a storage reservoir to contain the used nutrient solution until it can be removed by sewage truck.

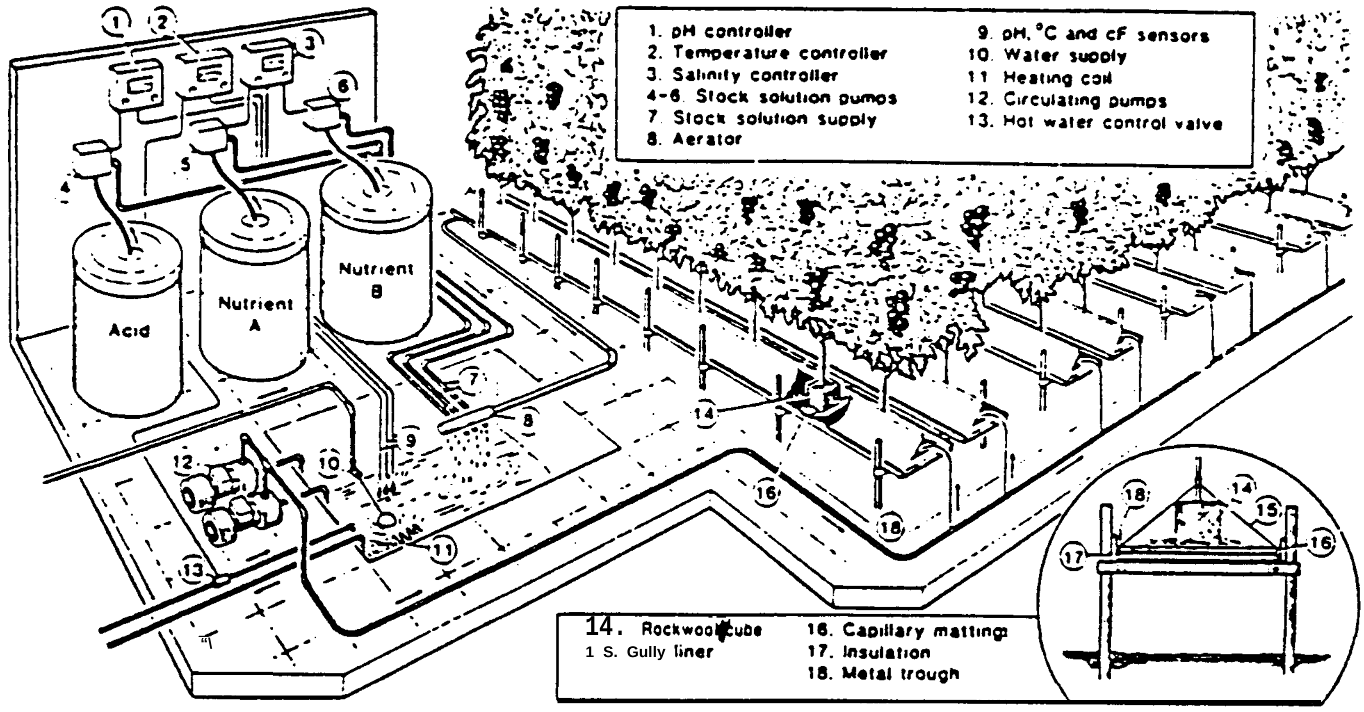
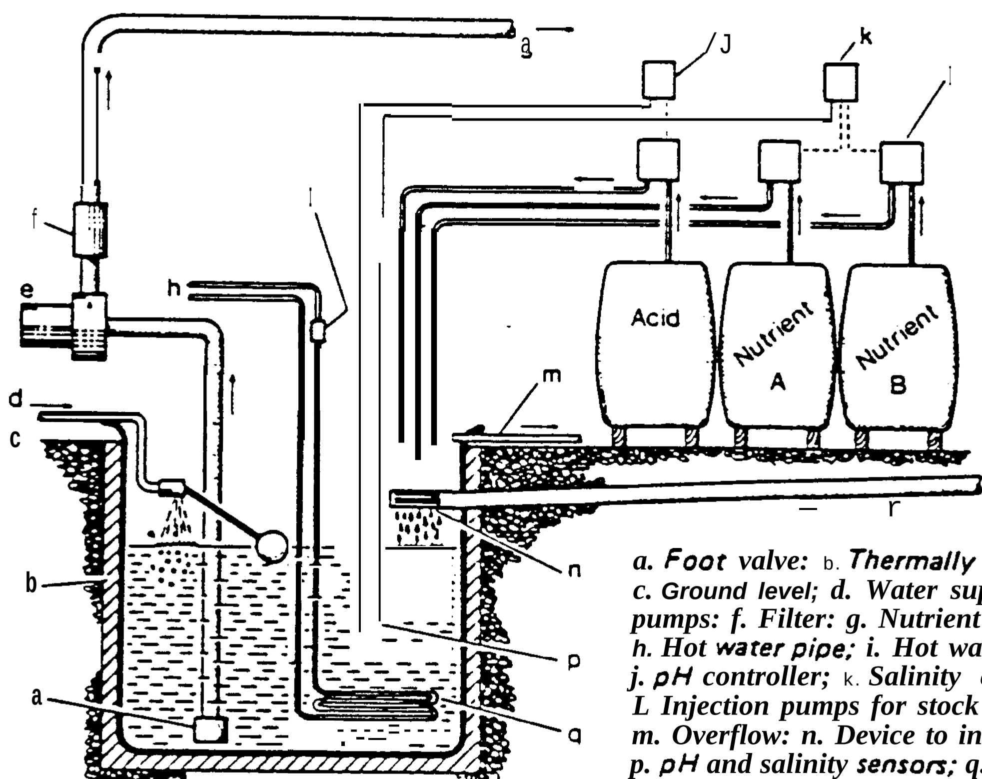


FIGURE 9 A **typical** NFT System (closed)

FIGURE 10 **Catchment tank and nutrient** supply system **for** hydroponic culture.



a. Foot valve: b. Thermally insulated tank; c. Ground level; d. Water supply; e. Circulating pumps: f. Filter: g. Nutrient supply to gullies; h. Hot water pipe; i. Hot water control valve; j. pH controller; k. Salinity controller: L Injection pumps for stock solutions: m. Overflow: n. Device to increase aeration; p. pH and salinity sensors; q. Heating coil; r. Return pipe from gullies.

FIGURE 11 A typical closed hydroponic system for NFT or **aggregate culture of plants.**

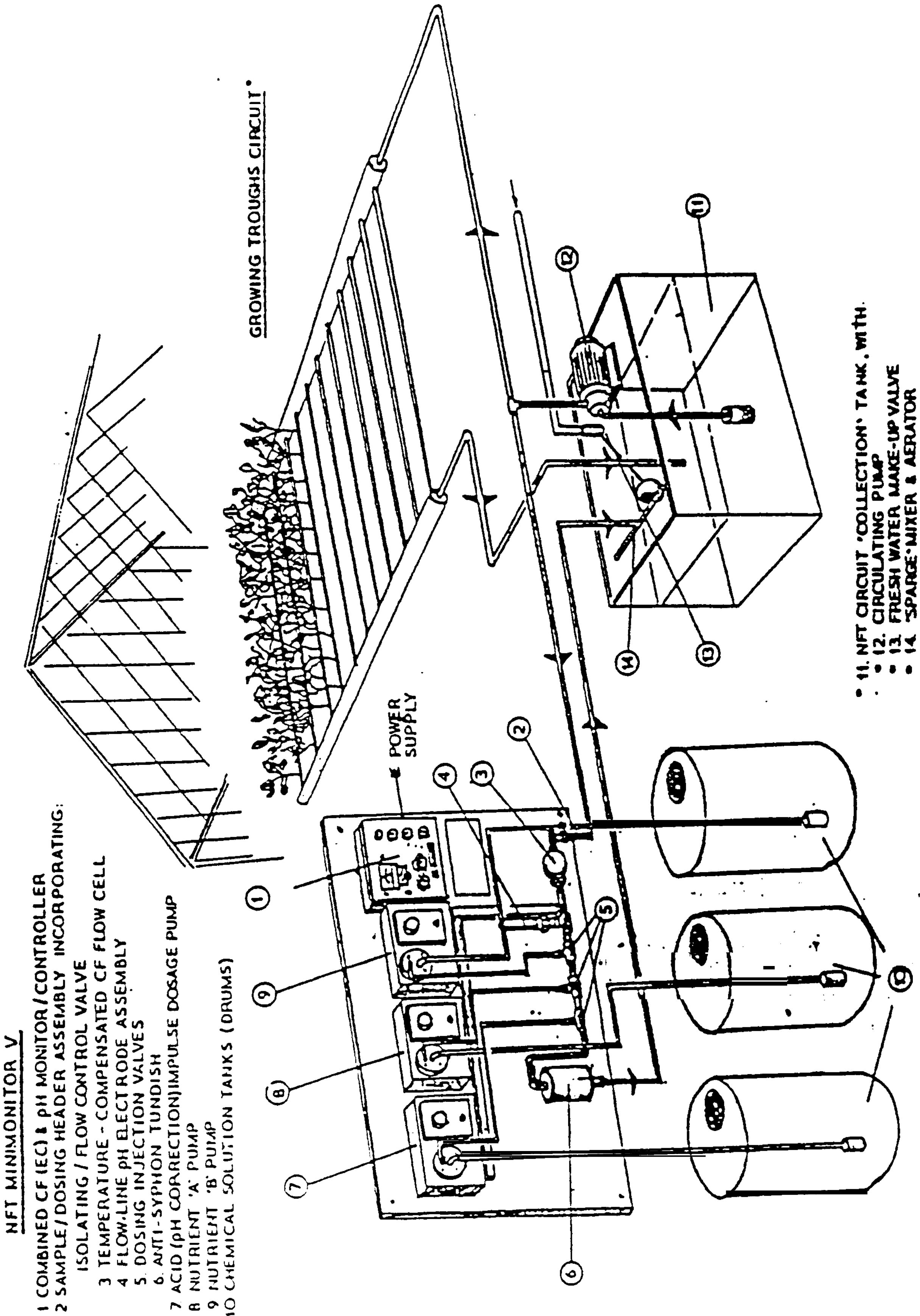
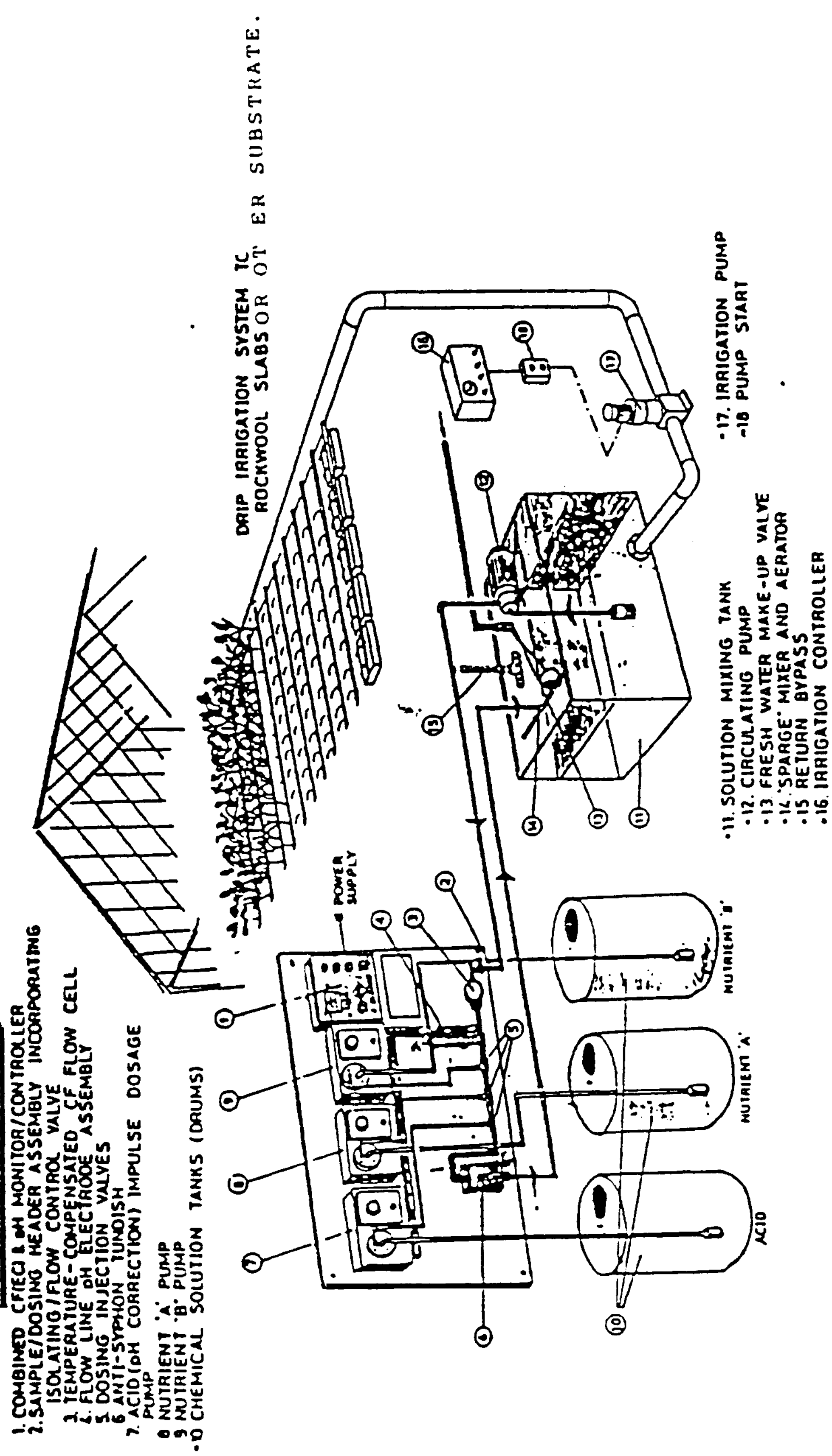


FIGURE 12 **A typical** open hydroponic system **for aggregate** culture of plants.



A wide range of equipment is available for growers in Canada. Many suppliers market stand-alone injector/mixer units which come complete with controllers, pumps, mixing tank, sand filter? sensors and injectors. For example, Growers Technical Servicesof Mississauga, Ontario offer the Vo 1 ma t i c automat i c mixer/irrigator which is capable of feeding two completely separate crops of bag or rock wool culture by alternating cycles of different nutrients. Other suppliers of complete systems include Metex Corporation of Weston, Ontario, Peter Zwart and Associates of Grimsby, Ontario, Canadian Hydrogardens Limited of Ancaster, Ontario and Harnois Industries of St Thomas, Quebec. (See list of suppliers in Appendix A).

The following lists itemize basic equipment requirements for the complete supply and control of nutrients and water. Each crop will require its own independent system as nutrient conditions and rates of applications vary between cucumber, tomato and lettuce plants. Small modifications are required for NFT versus Aggregate systems and these are pointed out. The pricing of complete system packages is covered in the economic section.

All systems have been scaled in size to permit an upgrading in greenhouse growing area to at least 10,000 ft2. This will enable future expansion of successful crops. It is also recommended that identical systems/components be purchased for all 3 crops to reduce in-stock requirements for spare parts. In the event of a breakdown of one system, emergency bypass valves can be installed to permit two crops to operate off one system.

1. NUTRIENT MONITORING AND ADJUSTMENT

- Polyethylene Tanks. : Two 1000 litre tanks are required for storage of fertilizer concentrates. (While in concentrated form, the calcium must be kept separate from sulfate and phosphate containing fertilizers).
- Stainless Steel Tank : One small tank is required for storage of concentrated Nitric acid (pH control)
- EC (Conductivity) Meters: One In-line meter is used to drive the nutrient injection metering pumps and one hand-held meter is used for spot checks at the plant.
- Multiple-Head Injection Pumps : to feed concentrated fertilizer and acid to catchment tank on command from EC and PH in-line meters.
- Controller for pH and EC regulation : may be computer or timer driven system.

- pH Meters : One In-line meter to drive the acid injection pump and one hand-held meter to check" the in-line meter.

NOTE: Hand-held pH and Conductivity meters are interchangeable between the three crops and only one of each is required. If a computer is used, it may be able to feed two crops of bag or rockwool culture (alternate cycles of feeding from two separate nutrient tanks). In NFT culture, each crop would require its own control system.

2. CATCHMENT TANK AND ACCESSORIES

- Catchment Tank : An insulated polyethylene tank of food grade with approximately 800 - 1000 litre capacity will be required for each crop.
- Heating Coil : Stainless steel water to water heat exchanger coils are recommended to maintain the constant temper- ature of the re-circulating solution.
- Thermostatic Control : For controlling the operation of the heating coil.
- Makeup water Supply : Fresh water makeup regulated by a standard float device. An estimated 2 litres/plant/day is required for NFT.
- Aerator : The returning nutrient solution is passed through a drip aerator which breaks up the water and increases the oxygen content of the solution.
- Ultra-Violet irradiator : Functions in pasteurization of water to reduce incidence of fungal pathogens.

3. WATER/NUTRIENT DELIVERY AND RECOVERY

- Circulating pumps : (primary and backup) Take nutrient solution from the catchment tank and send to planks.
- Sand Filter : Elimination of impurities and salts in the water Either stainless steel or polyethylene model is required and should be sufficiently large to filter water for all 3 greenhouses.
- PVC tubing and emitter lines : Different requirement= for NFT and substrate systems. See next section.
- Drip emitter= (2 to 4 litres/hour) : One per plant is required for both peat bag and rockwool systems.
- Recovery trough : Must be made of or lined with polyethylene to eliminate potential phytotoxic effects. See descriptions at start of this section.
- Storage tank : Recovery of used nutrient solution in an open hydroponic system (awaiting removal by sewage truck).

4.5 TECHNICAL SPECIFICATIONS AND LAYOUT OF LIGHTING FIXTURES

The lighting requirement= for the Greenhouses were worked out in consultation with FL Light Systems Canada and are summarized below. The calculation of total required hours of lighting can be found in section 5. Refer to Figures 13, 14, 15 and Tables 7, 8, 9 and 10 on following pages for more details regarding setup and specifications of fixtures.

TABLE 7 Specifications for lighting fixtures in greenhouse.

FL-780 fixtures @ 400 Watts	TOMATO	CUCUMBER	LETTUCE
Number of Rows	3	3	3
Distance between Rows	10'	10'	10'
Distance between fixtures in Row	6'5"	6'4"	4'10"
Mean Light Intensity (ftcd).	624	630	832
Uniformity of Light.........	84%	84%	85%
Minimum mounting height above crap (feet j	4 0"	4'0"	4‘(j“
Number of Fixtures Required :			
7,500 ft2	48	24	63
10,000 ft2	63	33	84

Note: Fixtures weigh 30 lbs each and are mounted on light steel U-track with brackets and couplings. Bulbs have a life expectancy of 5,000 hrs.

FIGURE 13 Floorplan for installation of lighting fixtures in tomato greenhouse (4,01313 ft2)

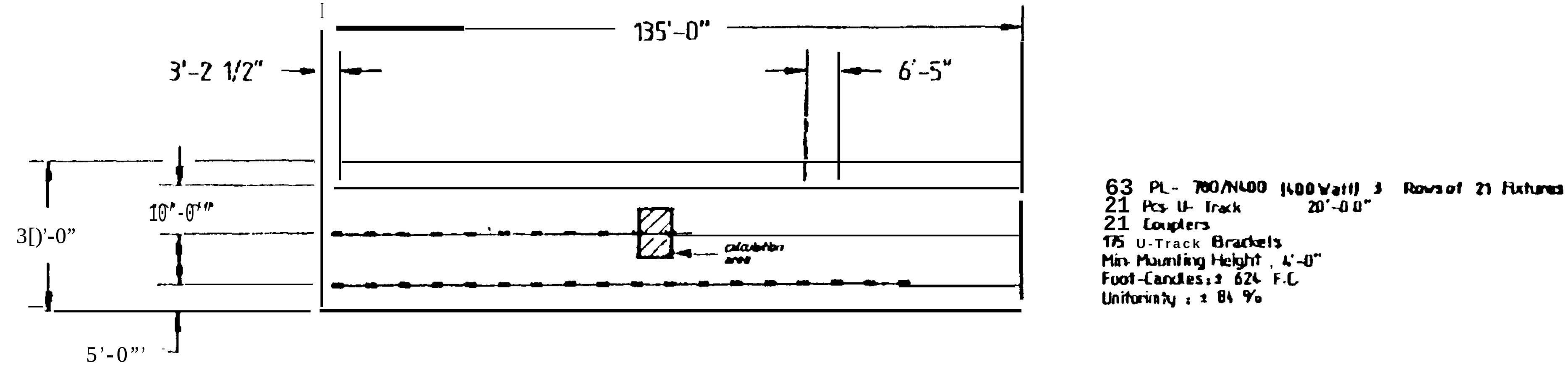


FIGURE 14 Floorplan for installation of lighting fixtures in lettuce greenhouse (4,000 ft2)

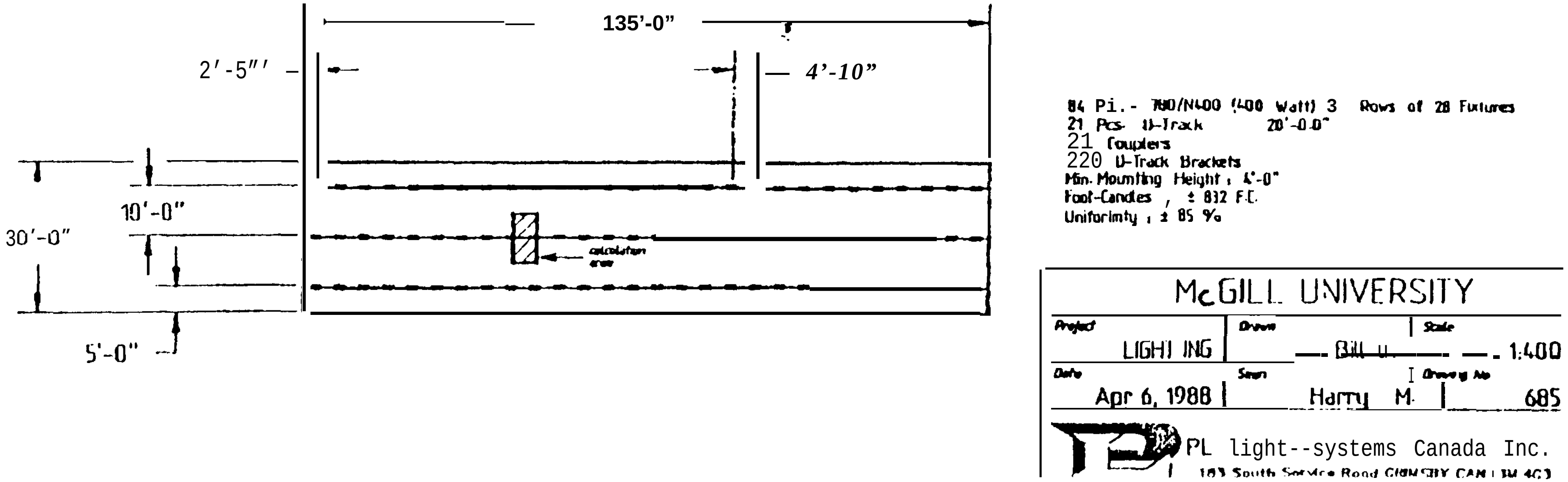
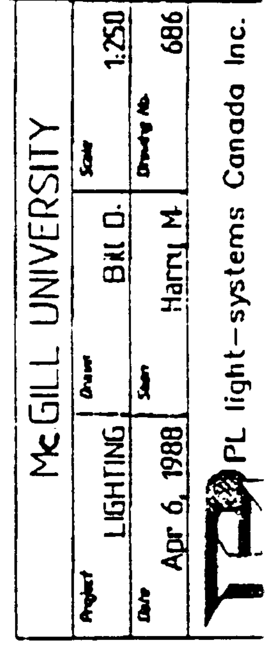


FIGURE 15 **Floorplan** for installation of lighting
in cucumber greenhouse (2,000 ft2)



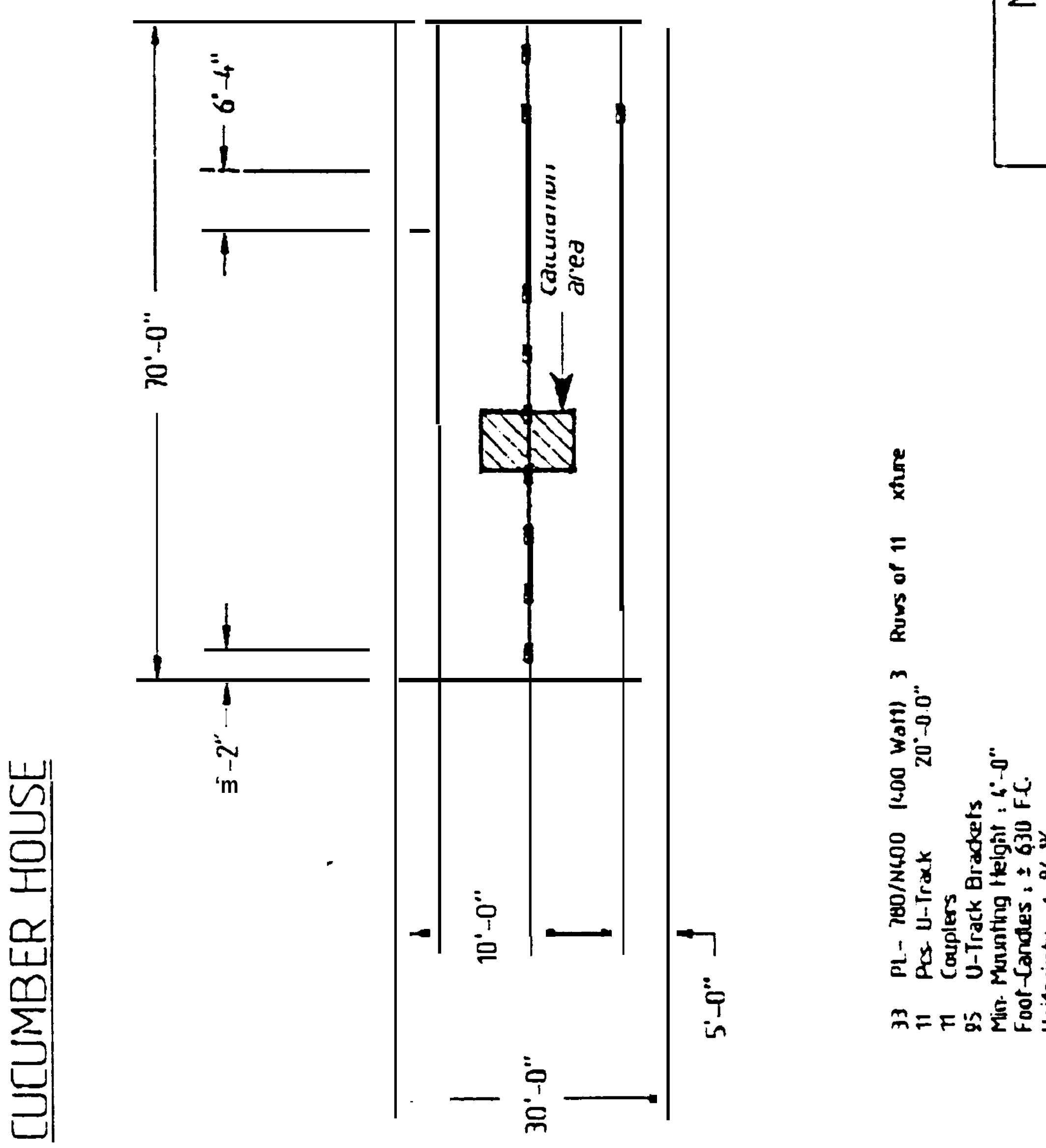


TABLE 8 Specifications (lightlevel and uniformity) for lighting fixtures in tomato greenhouse.

P.L Light Systems Canada Inc.
CALCULATION OF LIGHTLEVEL AND UNIFORMITY

PROJECT pl8/0U1/Bill : MaGill University (Tomato House) number: 01-03 date: 04-06-88
Configuration : PL-780/N400 (6.428' x 10.0')
Height : 4.0'

CALCULATION FIELD

spacing of calculation points:	in X direction	1.07'	in Y direction	1.00'
number of calculation points:	in X direction	7	in Y direction	11
level of calculation plane		0.00'		
orientation of calculation plane: horizontal				

LUMINAIRES ARRANGEMENT

	luminaires		first luminaire			intensity	luminous	aiming angles		
n	number	spacing (f!	x (f)	y (f)	z (f!	matrix	flux (klm)	azimuth	inclination	rotation
1	7	6,43	-19.28	5.00	4.00	840903	47.00	90.00	0.00	0.00
2	7	6,43	-19,28	15.00	4.00	840903	47.00	90.00	0.00	0.00
3	7	6.43	-19.28	-5.00	4.00	840903	47.00	90.00	0.00	0.00

ILLUMINANCE IN THE CALCULATION FIELD (Fcd)

	1*	2*	3*	4*	5*	6*	7*
1-	529.2	540.7	593.2	622.1	593.2	540.6	529.1
2-	533.4	543.0	593.8	628.8	593.7	542.9	533.3
3-	589.9	611.0	6S0,2	670.2	650.1	610.3	589,7
4-	614.4	672.8	664.4	706.0	664.4	672.7	614.2
5-	573.6	657.0	649.2	687.5	649.1	656.9	573.4
6-	564.5	646.7	559.?	673.5	658.8	646.6	564.3
7-	573.6	657.0	649.2	687.5	649.1	656.9	573.4
8-	614.4	672.8	664.4	706.0	664.4	672.7	614.2
9-	589.9	611.0	650.2	670.2	650.1	610.9	589.7
10-	533.4	543.0	593.8	628.8	593.7	542.9	533.3
11-	529.2	540.7	593.2	622.1	593.2	540.6	529.1

Illuminance: Emin = S29,1 Fcd Emax = 706.0 Fcd Eav = 624.1 Fcd
Uniformity: UG(Emin/Emax) = 74.9 % UO(Emin/Eav) = 84.8%

Emin = The minimum lightlevel in the field Emax = The maximum lightlevel in the field
Eav = The average lightlevel of the whole field UG = The minimum past maximum values
UO = The minimum past average values of the field (real uniformity !!)

This computer calculation has been made vith one exact measured reflector.
Because of this there will a difference with this computer calculation
and the values in practice.
This because 01 ; Greenhouse constructions, Voltage loss, Temperture and
most important factor the tolerance in bulbs and ballast units.

TABLE 9 Specifications (lightlevel and uniformity) for lighting fixtures in cucumber greenhouse.

P.L Light Systems Canada Inc.
CALCULATION OF LIGHTLEVEL AND UNIFORMITY

PROJECT p16700!/bill : McGill University (Cucumber House) number: 01-02 date: 04-06-88
Configuration : PL-780/N400(6.36' x 10.0')
Height : 4.0'

CALCULATION FIELD

spacing of calculation points: in X direction 1.06' in Y direction 1.00'
number of calculation points: in X direction 7 in Y direction 11
level of calculation plane , 0.00'
orientation of calculation plane: horizontal

LUMINAIRES ARRANGEMENT

luminaires			first luminaire			intensity	luminous	aiming angles		
n	number	spacing (f)	x (f)	y (f)	z (f)	matrix	flux (klm)	azimuth	inclination	rotation
1	7	6,36	-19.08	5*00	4.00	840903	47.00	90.00	0.00	0.00
2	?	6.36	-19.08	15.00	4.00	840303	47.00	90.00	0.00	0.00
3	1	6.36	-19.08	-5.00	4.00	840903	47*00,	90.00	0.00	0.00

ILLUMINANCE IN THE CALCULATION FIELD (Fcd)

	1*	2*	3*	4*	5*	64	7*
1-	533.3	546.0	600.0	631.1	600.0	545.9	533.1
1-	537.9	548.0	600.8	635.1	600.8	547.9	537.7
3-	594.1	616.1	658.1	680.1	658.1	616.0	593.9
4-	618.1	678.3	673.4	715.9	673.4	678.1	617.9
5-	577.2	662.6	658.6	696.0	658.5	662.5	577.0
6-	568.1	651.3	669.5	687.8	669.4	651.2	567.9
7-	577.2	662.6	658.6	696.0	658.5	662.5	577.0
8-	618.1	678.3	673.4	715.9	673.4	678.1	617.9
9-	594.1	616.1	658.1	680.1	658.1	616.0	593.9
10-	537.9	548.0	600.8	636.1	600.8	547.9	537.7
11-	533.3	546.0	600.0	631.1	600,13	545.9	533*1

Illuminance: Emin = 533.1 Fcd Emax = 715.9 Fcd Eav = 630.8 Fcd
Uniformity: UG(Emin/Emax)= 74.5 % UO(Emin/Eav)= 84.5%

Emin = The minimum lightlevel in the field Emax = The maximum lightlevel in the field
Eav = The average lightlevel of the whole field UG = The minimum past maximum values
UO = The minimum past average values of the field (real uniformity !!)

This computer calculation has been made with one exact measured reflector.
Because of this there will a difference with this computercalculation
and the values in practice.
This because of : Greenhouse constructions, Voltage loss, Temperture and
most important factor the tolerance in bulbs and ballast units.

TABLE 10 Specifications (lightlevel and uniformity) for lighting fixtures in lettuce greenhouse.

P.L Light Systems Canada Inc.
CALCULATION OF LIGHTLEVEL AND UNIFORMITY

PROJECT p187001/Bill : McGill University (Lettuce House) number: 01-01 date: 04-06-89
Configuration : PL-780/N400 (4.82'x 10.0')
Height : 4.0'

CALCULATION FIELD

spacing of calculation points: in X direction 0.96' in Y direction 1.00'
number of calculation points: in X direction 6 in Y direction 11
level of calculation plane 0,00'
orientation of calculation plane: horizontal

LUMINAIRES ARRANGEMENT

n	luminaires number	luminaires spacing (f)	first luminaire x (f)	first luminaire y (f)	first luminaire z (f)	intensity matrix	luminous flux (klm)	aiming angles azimuth	aiming angles inclination	aiming angles rotation
1	7	4.82	-14.46	5.00	4,00	840903	47.00	90.00	0,00	0.00
2	7	4,82	-14.46	15.00	4.00	840903	41.00	90.00	0.00	0.00
3	7	4.82	-14.46	-5.00	4.00	840903	47.00	90.00	0.00	0.00

ILLUMINANCE IN THE CALCULATION FIELD (fcd)

	1*	2*	3*	4*	5*	6*
1-	719.4	737.7	806.4	806.3	737.4	718.8
2-	712.?	744.6	803.8	803.7	744,3	712.3
3-	773.4	821.5	896.0	895.8	821.2	772.8
4-	789.4	893.9	931.7	931.6	893.6	788.7
5-	752.4	863.0	896.0	895.9	862.5	751.8
6-	739.7	855.4	906.3	9&7	565.0	739.1
7-	752.4	883.0	896.0	895.9	862.5	751.8
8-	789.4	893.9	931.7	931.5	893.5	788.7
9-	773.4	821.5	895.0	895.8	821.2	772.8
10-	712.9	744.6	803.8	803.7	744.3	712.3
11-	719,4	737.7	806.4	806.3	731,.4	718.8

Illuminance: Emin = 712.3 Fcd Emax = 931.7 Fcd Eav = 832.4 Fcd
Uniformity: UG(Emin/Emax)= 76.4 % UO(Emin/Eav)= 85.6%

Emin= The minimum lightlevel in the field Emax = The maximum lightlevel in the field
Eav = The average lightlevel of the whole field UG = The minimum past maximum values
UO = The minimum past average values of the field (real uniformity !!)

This computer calculation has been made with one exact measured reflector.
Because of this there will a difference with this computer calculation and the values in practice.
This because of : Greenhouse constructions, Voltage loss, Temperture and most important factor the tolerance in bulbs and ballast unit;.

4.6 OPTIONAL OUTDOOR GREENHOUSE DESIGNS AND SETUP

Outdoor cultivation can be easily undertaken using local soil resources and simple plastic covered Quonset-type greenhouses. Some simple models are available from Harnois Ltd. of Montreal. "Ovaltech", "Plastigro" and "Econoshelter" are among the most popular models used in Quebec. See Figure 10. The structures have passive ventilation through gable end windows and sidevents if necessary. A small oil fired heater may be considered to prolong the season by protecting plants from night frost in spring and fall.

Plants would be grown in local soil beds framed with plywood sides. Both the initial construction and preparation of the beds as well as the subsequent operation of the greenhouse are labour intensive and would provide an excellent employment and training opportunity for high school students and horticultural trainees. Seedlings for the seasonal crops would be pre-germinated in the propagation room and set out once danger of frost had passed. The subsequent care, watering and harvest of crops would be undertaken by hired helpers.

Local soil components which may be used include:

1. FINE SAND which may be found at the edges of lakes and river=:

2. ORGANIC PEAT (partly decomposed) which occur-s where the tundra has been disturbed as well as the edges of rivers and streams:

3. ORGANIC LAKE SEDIMENTS which accumulate along the edges of lakes (composed of dead insect, fish and plant matter) .

Local soil mixtures should be sifted to remove roots, large rocks and provided with a regular fertilization schedule to supply plant nutrient requirements.

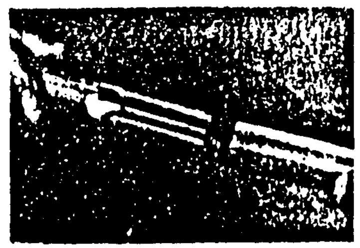
FIGURE 16a Harnois quonset-type greenhouse suitable for indoor Vegetable production in arctic regions.

OVALTECH

Gothic shape really performs: the strength of the gothic arch combined with our unique curved braces eliminates snow accumulation at the peak. Also condensation won't "hang". It will run down the poly.

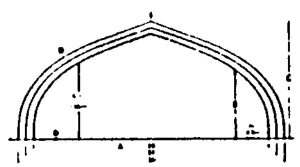
The Harnois greenhouse with its curved purlin design prevents condensation "rain" forever. Condensation droplets form and run all the way down the poly to the ground. Structure comes with 1¼" square purlins when used with rigid covering.

Oval tubes are 20% stronger than round combining the strength of square with the quality of round, reducing wear on poly.



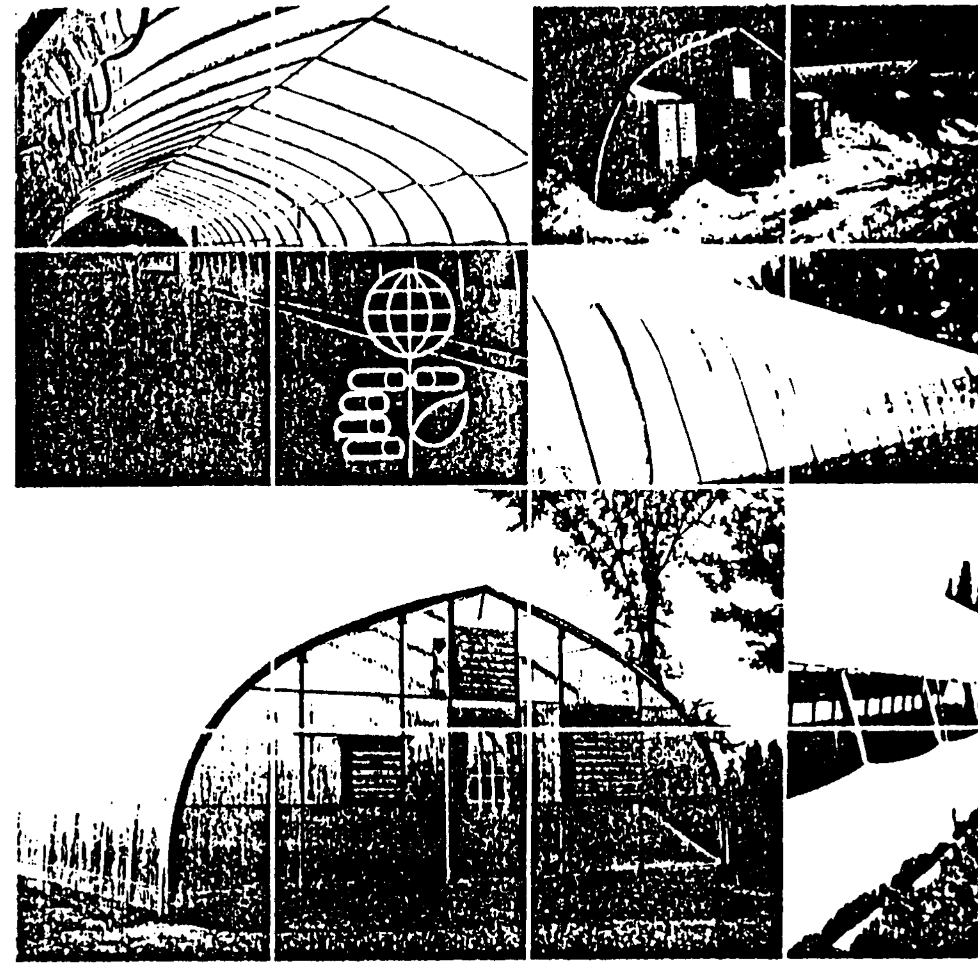
Most parts are pre-drilled. Top union and post are swedged, and slip into one another.

The professional's choice, constructed entirely with pre-galvanized steel, this structure is available in 25', 27' and 30' widths. Ribs are 5' apart on all these models. Also available is a 25' wide tunnel with an 8' rib spacing.



A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
B	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The specifications as stated herein are the most current at the time of publication and are subject to modification without notice. We reserve the right to change the design without notice or obligation on our part to modify any equipment previously sold or delivered.



Harnois Industries Inc.
1044 Main St., Saint-Thomas-Joliette,
P.O. Box 150, Qc, Canada J0K 3L0
Tel. (514) 756-1041
Fax. (514) 756-8180
Telex 05-26742 (Harnois STJ)

OVALTECH

HARNOIS

FIGURE 16b Harnois quonset-type greenhouse suitable for outdoor vegetable production in arctic regions.

OVALTECH

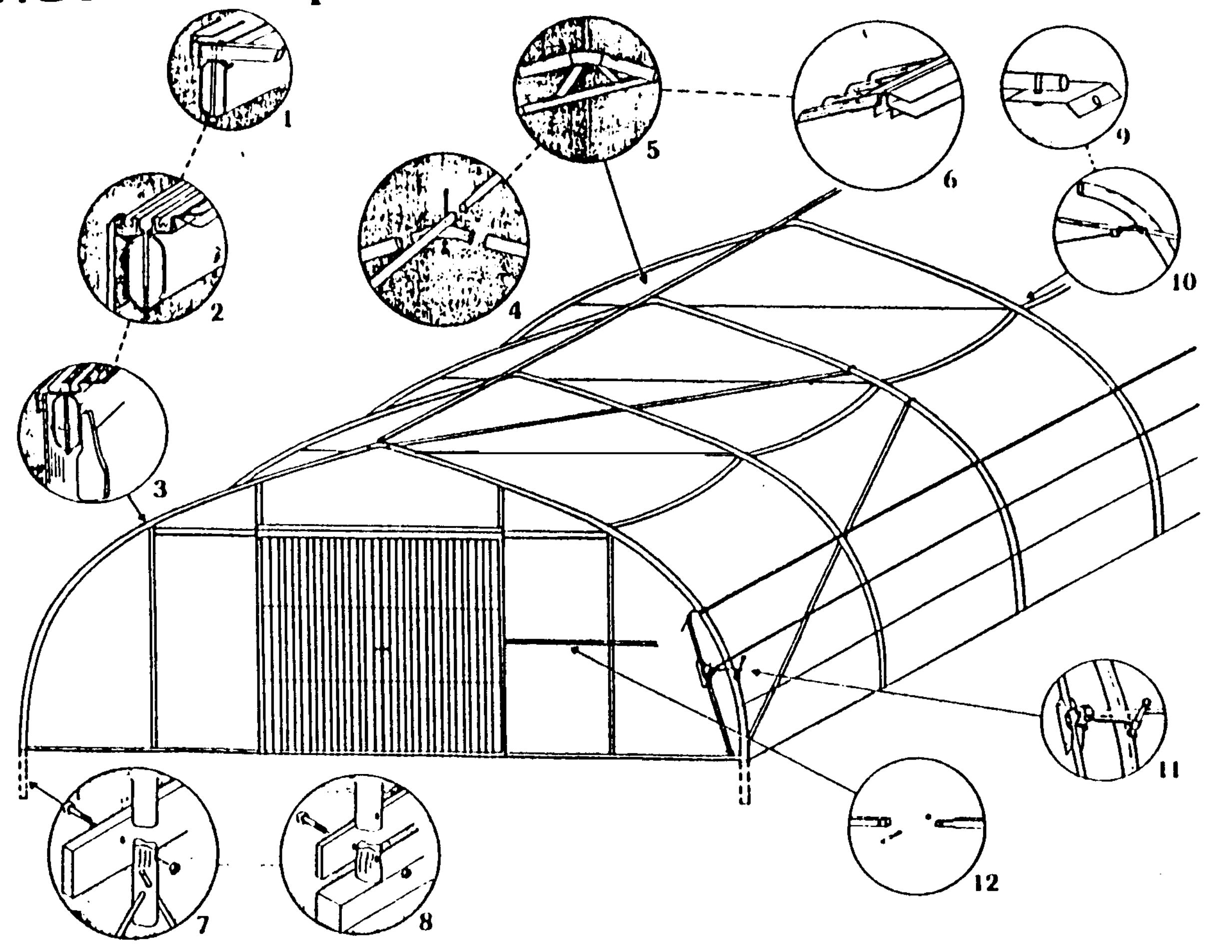
Choice of crop supports for your particular needs, either 1"Ø crop (fig.9) supports with 2 hangers or 5/16"Ø cross tie. Using these supports also adds strength to your structure.

Natural ventilation is provided by optional roll-up side walls up to 300' in length (fig.11). A special hand crank mechanism makes this system easy and effortless to operate.

Steel gable ends are now easier than ever to install. Gable end studs are oval and specially formed at one end for easy mounting. Flush with the end rib (fig.3). 1¼" Ø Purlins with one swedged end, eliminate weak gaps (fig. 12)

Gable end ribs are adaptable to your choice of coverings. The end rib comes with

...Gothic Shape....Ova Tube....Curved Purlins...



...Comes with many original features....Designed with you in mind...

either a double vinyl flashing for glazing roofs and gable ends (fig.1), or a double extruded polylock for poly on roofs and gable ends (fig.2) or it comes with a single vinyl flashing for poly roofing and rigid covers on gable ends (fig.3)

Ridge tube is positioned for maximum poly life. The tube is fastened above the top union when double inflated poly is used (fig.4) or fastened below the top union for single poly applications (fig.5) to minimize abrasion. Also, an aluminum ridge extrusion is available for hard covers (fig.6)

Choose from 3 types of foundations for all situations: ground tube foundation comes with galvanized steel rods (fig.7) tubes for concrete foundation (standard) (fig.8) base plates for existing foundations

OVALTECH

HARNOIS

SECTION 5

TEMPERATURE, LIGHTING AND OTHER CULTURAL REQUIREMENTS FOR PRODUCTION

In this section, the hydroponic culture of the three selected vegetables will be briefly discussed particularly with respect to mechanical and structural requirements (temperatures, lighting Co2 Generation). Detailed descriptions of growing conditions, recommended procedures and practices will not be described in this report, but suitable reference material and sources are recommended in Appendix A and B.

5.1 PROPAGATION OF PLANTS

— 7 A number of methods are avaialble for initiating plant seedlings in soilless culture. Generally, crops to be grown in inert substances should be initiated in similar materials. For plants growing in rockwool, smaller "germination cubes" are available. Rockwool cubes and similar "Oasis Horticubes" are also utilized to start seedlings for NFT culture. Plants grown in bag culture may be initiated in many media including Jiffy peat pellets, peat-lite mixes, rockwool cubes and vermiculite.

The germination media is well saturated before planting out seed and bottom heating is generally used to maintain critical temperatures required for germination. After germination, seedlings are grown under artificial lights with frequent irrigation to prevent them from drying out. Once sufficient root production has occurred, the seedlings may be set out in the NFT gutters, peat bags or rockwool cubes.

Since the germination and growth of seedlings and young plants may extend to 12 weeks for tomato and cucumber, and since space and lighting requirements are much lower than for mature plants, this phase of growth may be carried out in a separate "propagation area" with artificial lighting. Lettuce seedlings spend only a short period under similar conditions before being set out into NFT gullies.

It is recommended that the design of the greenhouses incorporate a room for the growth of seedlings on benches supplied by bottom heating. Since 100% artificial illumination will be used, sufficient heat may be generated by the lamps to heat the air layer above the plants leaving only the root zone to be considered. A number of systems are commercially available for this purpose including Vary Industries' ROOT ZONE tm system which pumps hot water through a network of rubber capillary tubing laid directly under the benchtop.

An estimated 150 to 200 ft2 of bench space will be required immediately for growing tomato plants. This value would increase to almost 500 ft2 if the greenhouse growing area were expanded from the present 4,000 to 10,000 ft2. Similarly, cucumber plants would presently require 100 ft2 of bench space to grow young plants, and eventually 500 ft2 if expansion to a greenhouse area of 10,000 ft2 occurred. Lettuce seedlings require much less space and the propagation area may be incorporated into the production greenhouse since year-round operation is anticipated.

5.2 TEMPERATURE AND HUMIDITY DURING CULTIVATION OF CROPS

The temperature and humidity requirements for the greenhouse production of tomatoes and cucumbers are similar whether soil or soil less culture is utilized. In soil less culture however, the temperatures of the nutrient solution and root zone are as important as air temperatures in the greenhouse. In fact, recent studies have demonstrated that nighttime air temperatures may be lowered as much as 10°C below daytime levels providing solution temperatures are heated (Mueller 1982). This results in considerable energy savings to greenhouse operators.

At present, the optimum solution temperature recommended for NFT and rockwool culture is between 20° and 25°C (Resh 1981). This applies for all three crops and for all culture systems.. Air temperatures are varied between the three crops and their stages of development. The table on the following page summarizes average temperatures used in the production of greenhouse craps.

TABLE 11 Temperatures recommended for the cultivation of lettuce, cucumber and tomato

CROP		DAY	NIGHT
LETTUCE (Bibb)	Cloudy days	13°C	8°- 10°C
	Sunny days	14°- 17°C	8°- 10°C
TOMATO	Germination	20°- 22°C	20°- 22°C
	Cold Treatment (Selected Varieties)	13°C	10°- 12°C
	Fruiting & Flowering		
	Cloudy days	17°C	16°C (*)
	Sunny days	18° - 26°C	16°C (*)
CUCUMBER	Cloudy days	23°- 27°C	20°- 23°C
	Sunny days	25°- 30°C	21°- 25°C

(*)NOTE : Night temperatures may be lowered as low as 5°C if solution temperature is warmed to 26°C (Mueller 1982)

The orientation of the heating system in the greenhouse should follow the same layout as the plant rows. Hot water pipes are typically placed adjacent to the double rows of plants in a tomato/cucumber greenhouse. This arrangement contributes to:

1. Increasing the root zone temperature
2. Improving heat distribution to plants
3. Improving air circulation around plants
4. Decreasing humidity in lower half of greenhouse

Hot water may also be circulated through PVC tubing placed directly under rockwool slabs or peat bags to contibute to even and ample heating of the root zone. (not applicable for NFT).

During the winter months, reduced ventilation to the outdoors may result in poor circulation of greenhouse air and increased levels of humidity. This may pose serious problems for the crop if not controlled. Several options are available:

1. Installation of an air to air heat exchanger may reduce humidity levels sufficiently and also introduce fresh CO2 required by plants for production.

2. Installation of positive pressure fans to mix the air in the greenhouse.

3. Assuming surplus heat is available, initiate a simultaneous heating and venting to "burn off" the air and draw out excess humidity.

5.3 CO2 CONTROL AND ENHANCEMENT

Most commercial vegetables growers have some system to increase ambient Carbon Dioxide levels inside the greenhouse. CO_2 addition is particularly important during cold periods (such as winter) when ventilators are closed. At these times, internal CO_2 levels may drop to 200 ppm within one hour. Such low levels of available gas seriously limit the crops ability to produce. Optimal levels of Production may be maintained if CO_2 concentrations of close to 1000 ppm are supp lied by propane burning generators.

A number of CO_2 generators are available commercially, of particular noteworthiness is the newly introduced PRIVA model which comes complete with controller for accurate monitoring of ambient CO_2 levels in the greenhouse. CO_2 generators are typically suspended in the center of the greenhouse from structural members.

5.4 NUTRITION OF SOILLESS CULTURE

The single most important requirement for successful hydroponic culture is crop nutrition. Most of the information utilized by commercial hydroponic growers in Ontario has been developed at the Glasshouse Crops Research and Experiment Station, Naaldwijk, in the Netherlands. Compositions of essential elements and basic nutrient solutions for use in substrate culture of tomato and cucumber are well documented in the OMAF publication entitled "Basic Nutrition of Substrate Culture" W. A. Straver and F. J. Ingratta, Harticultural Research Institute of Ontario, Vineland Station, Ontario.

The most common method for feeding plants is the "complete method" where all the essential elements are provided on a daily basis in a dilute solution along with the plants water. This method utilizes the equipment described in the previous section and permits the grower to adjust nutrient levels on a daily level according to stage of development and external weather conditions.

One of the primary requirements of hydroponic culture is that the irrigation water be of suitable quality. A water analysis is an important first step in determining the feasibility of the operation. The electrical conductivity (EC) is the most important criterion for determining water quality. It is generally accepted that an EC of 0.5 mS/cm is ideal for hydroponic culture while levels of up to 1.0 mS/cm are acceptable providing certain adjustments are made to the nutient solutions. in addition to EC levels, the presence of high concentrations of Sodium (Na^+ > 30 ppm) or Chlorine (Cl > 50 ppm) may render the water unacceptable for successful culture.

Based on the results of the preliminary water test, the nutrient solution is adjusted to compensate for deficiencies or excesses in the water status. Users have the option of puchasing individual chemical= and mixing their own concentrated stocks or alternately, buying "ready-to-use" concentrated mixes - Hydrogardens Inc of Colorado Springs, CO, supplies several kinds of "CHEM-GRO" tm liquid fertilizers specifically designed for tomato, cucumber or lettuce culture. In Canada, Canadian Hydrogardens Ltd also provides a wide assortment of single element or blended fertilizer's to growers and as a bonus, provides free horticultural consultation and reduced rate water and tissue analysis to users of it= products.

In addition to the regular feeding of the crop, periodic adjustments to the nutrient solution must be made on the basis of:

- Visual observations of deficiency symptoms. Growers may benefit from numerous publications including : "Nutritional Disorders in Glasshouse Tomatoes, Cucumbers and Lettuce" J.P.L. Roorda van Eysinga and K.W. Smiide (available from Hydrogardens, Inc. Colorado Springs, CO)

  Regular tissue and water sample analysis performed at a Feud 1 aboratory (several are available in southern Ontario). These analyses must be performed within 24-48 hrs of taking the sample and will have to be sent by courier service. The results of the sample should be discussed with a qualified horticulturalist. This service is also available from several consulting agencies including Canadian Hydrogardens.

- Changes in stage of plant and external weather conditions.

Water volume of the closed system can be estimated at approximately 20,000 litres/acre of which only 15% - 20% is maintained in the catch ment tank. The daily makeup of water is estimated at approximately 2 litres / plant /day for a mature crop.

If an open system is used, water requirements will be considerably increased and the problem of water removal will have to be considered.

5.5 SUPPLEMENTARY LIGHTING OF CROP PLANTS

Studies at the University of Laval have demonstrated that increases of up to 100% in yields of tomato may be obtained with the addition of supplementary lighting to greenhouse crops. The optimum photoperiod for the crops to be grown is as follows:

TOMATO . . . . . 14 hrs
CUCUMBER . . . 17 hrs
LETTUCE . . . . 16 hrs

During the summer and spring months, plants will benefit from sufficient natural light and will not require supplementary lighting. In fact, both cucumber and lettuce can be expected to grow well under the 24 hr photoperiod of the arctic summer day. Tomatoes may require a short period of darkness (as little as 4 hrs) particularly when they are young plants. It may therefore be necessary to provide "black-out" curtains to the proposed tomato house to improve growth.

During the fall and winter months, supplementary lighting will play an integral role in providing the necessary light to growing plants. The following tables summarize the daily and monthly hours of artificial lighting that will be required for each crop.

TABLE 12 Monthly hours of supplementary lighting required for production of tomato in Iqaluit.

TOMATO [14 HOUR PHOTOPERIOD REQUIRED]

MONTH/DAYS		AVERAGE NATURAL DAYLIGHT HOURS	HOURS OF SUPP. LIGHTING/DAY	HOURS OF SUPP. LIGHTING/MONTH
JANUARY	31	6 hrs (*)	10 hrs	310 hrs
FEBRUARY	28	8 hrs (*)	8 hrs	224 hrs
MARCH	31	12 hrs	2 hrs	62 hrs
APRIL	30	14 hrs	0 hrs	0 hrs
MAY TO AUGUST		> 16 hrs	no supplementary lighting required	
SEPTEMBER	30	12 hrs	2 hrs	60 hrs
OCTOBER	31	10 hrs	4 hrs	124 hrs
NOVEMBER	30	6 hrs (*)	10 hrs	300 hrs
DECEMBER	31	5 hrs (*)	11 hrs	341 hrs

TOTAL HOURS OF SUPPLEMENTARY LIGHTING REQUIRED FOR :

8 MONTH GROWING SEASON (MAR-OCT) = 246 hrs
12 MONTH GROWING SEASON .... = 1,421 hrs

(*) During these winter months, the natural light intensity may not be sufficiently strong to maintain high production levels and for this reason, a 25% increase in hours of supplementary hours will be incorporated in the estimates.

TABLE 13 Monthly hour-s of supplementary lighting required for production of cucumber in Iqaluit.

CUCUMBER [17 HOUR PHOTOPERIOD REQUIRED]

MONTH/DAYS		AVERAGE NATURAL DAYLIGHT HOURS	HOURS OF SUPP. LIGHTING/DAY	HOURS OF SUPP. LIGHTING/MONTH
JANUARY	31	6 hrs (*)	14 hrs	434 hrs
FEBRUARY	28	8 hrs (*)	11 hrs	308 hrs
MARCH	31	12 hrs	5 hrs	155 hrs
APRIL	30	14 hrs	3 hrs	90 hrs
MAY TO AUGUST		> 10 hrs	no supplementary lighting required	
SEPTEMBER	30	12 hrs	5 hrs	150 hrs
OCTOBER	31	10 hrs	7 hrs	217 hrs
NOVEMBER	30	6 hrs (*)	14 hrs	420 hrs
DECEMBER	31	5 hrs (*)	15 hrs	465 hrs

TOTAL HOURS OF SUPPLEMENTARY LIGHTING REQUIRED FOR :

8 MONTH GROWING SEASON (MAR-OCT) = 612 hrs

12 MONTH GROWING SEASON .... = 2,239 hrs

(*) During these winter months, the natural light intensity may not be sufficiently strong to maintain high production levels and for this reason, a 25% increase in hours of supplementary hours will be incorporated in the estimates.

TABLE 14 Monthly hours of supplementary lighting required far production of lettuce in Iqaluit.

LETTUCE [16 HOUR PHOTOPERIOD REQUIRED]

MONTH/DAYS		AVERAGE NATURAL DAYLIGHT HOURS	HOURS OF SUPP. LIGHTING/DAY	HOURS OF SUPP. LIGHTING/MONTH
JANUARY	31	6 hrs (*)	13 hrs	403 hrs
FEBRUARY	28	8 hrs (x)	10 hrs	280 hrs
MARCH	31	12 hrs	4 hrs	124 hrs
APR IL	30	14 hrs	2 hrs	60 hrs
MAY TO AUGUST		> 16 hrs	no supplementary lighting required	
SEPTEMBER	30	12 hrs	4 hrs	120 hrs
OCTOBER	31	10 hrs	6 hrs	186 hrs
NOVEMBER	30	0 hrs (*)	13 hrs	390 hrs
DECEMBER	31	5 hrs (*)	14 hrs	434 hrs

TUTAL HOURS OF SUPPLEMENTARY LIGHTING REWIRED FOR :

8 MONTH GROWING SEASON (MAR-OCT) = 490 hrs

12 MONTH GROWING SEASON .... = 1, 997 hrs

(*) During these winter months, the natural light intensity may not be sufficiently strong to maintain high production levels and for this reason, a 25% increase in hours of supplementary hours will be incorporated in the estimates.

TOMATO

An increasing number of tomato varieties are being developed for hydroponic culture. Most varieties are selected for resistance to the major diseases (tobacco mosaic virus (TMV), leaf moid (caused by *Cladosporium fulvum* Cke.), fusarium, and verticillium) The following varieties are good starting points for the northern grower:

1.	VENDOR	5.	DOMBITO
2.	TROPIC	6.	LAURA
3.	CARUSO	7.	PERFECTO
4.	JUMBO		

CUCUMBER

European cucumbers are the most common varieties grown in greenhouses. Selection of varieties resistant to powdery mildew is recommended. Some of the varieties available for hydroponic culture are :

1.	CORONA	4.	FIDELIO IMPROVED
2.	TOSKA	5.	PROFITA
3.	FARBIO	6.	MARILLO

LETTUCE

Bibb lettuce is the most successful under hydroponic cultivation. When selecting potential varieties, look for resistance to tip-burn, bolting and corky root. The following varieties are available:

1. OSTINATA (Summer Production)
2. SALINAS (Spring and summer)
3. RAVEL (Winter production}
4. MONTELLO

Looseleaf varieties are also available. These include:

1. BLACK SEEDED SIMPSON
2. DOMINEER
3. WALDMANN'S DARK GREEN

5.7 PRODUCTION SCHEDULES

There are many methods which may be used to cultivate tomato, cucumber and lettuce. Each grower will over time, develop and refine their own technique based on the type of greenhouse, growing system utilized, time of year and past experiences. A number of possible schedules are presented here as a reference but the definitive course will be taken by the horticulturalist responsible for the management of the crops.

TOMATO AND CUCUMBER

(A) 8 MONTH SEASON / SINGLE PLANTING

December	:	Germination and Growth of Seedlings 4 to 6 weeks [Propagation Room 3 (100% artificial illumination)
January February	:	Growth of transplants . . 8 weeks [Propagation Room 3 (100% artificial illumination)
March to October	:	Crop Output (Total 32 weeks) (Primarily natural light with supplemental lighting during March and September/October)
November	:	Clean up of greenhouse and Preparation for: 1. Next Crop Season (December) 2. Overwintering of Greenhouse (Dec-Feb)

(B) 12 MONTH SEASON / MULTIPLE PLANTINGS

An estimated 3 plantings over 12 months may be used to ensure continuous production of fruits from plants. Each cycle may look like this:

Month 1 to Month 3 : Sow seeds of plants and grow seedlings and transplants under artificial (or natural) lighting in the propagation area. (Total 8 - 12 weeks depending on crop)

Month 4 to Month 7 : Plant out in greenhouse and grow/ harvest (total time in greenhouse = 4 months)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PROPAGATION :	AAAAAAA		BBBBBBBBBBB				CCCCCCCCCCC				AAA	
GREENHOUSE :	CCCCCCC	AAAAAAAAAAAAAAA			BBBBBBBBBBBBBBB				CCCCCCC			

Plants are grown in alternating rows in the greenhouse, so that as one plant reaches maturity, the next cycle is planted alongside ensuring maximal' space utilization and even production from all parts of the greenhouse.

LETTUCE

Lettuce plants may be harvested and planted out in a continuous cycle depending on the weekly market demand. A regular process of channel rotation will be established after the length of the crop growing period is established. As each row is harvested from one end of the continuous conveyor (see Figure 2), an equal amount of rows (with seedlings) may be added to the other end of the conveyor.

1. HARVEST OF MATURE LETTUCE PLANTS → 2. CLEANING AND STERILIZING OF CHANNELS LIBERATED → 3. SOWING OF NEW SEEDLINGS IN CHANNELS → 4. PRODUCTION TIME OF 8 WEEKS + 1.

SECTION 6

CAPITAL AND ANNUAL OPERATING COSTS FOR DIFFERENT PRODUCTION SCENARIOS

In this section, the capital costs of the various growing systems and greenhouse size options will be estimated as well as the potential annual operating costs for each scenario.

6.1 CAPITAL COSTS

Capital casts will be divided into two components:

(A) BASE COSTS which are required for each individual greenhouse regardless of scale (up to 10,000 ft2). These include the controllers, nutrient injection system and storage tanks.

(B) AREA COSTS which are computed on a square foot basis and will be directly proportional to the scale of the greenhouse growing surface.

The tables on the following pages will summarize the capital costs for:

1. NFT HYDROPONIC SYSTEMS (Tomato, Cucumber, Lettuce)
2. PEAT BAG/ ROCKWOOL CLOSED SYSTEMS (Tomato, Cucumber)
3. PEAT BAG/ ROCKWOOL OPEN SYSTEMS (Tomato, Cucumber)
4. LIGHTING AND CO2 COSTS (All crops and systems)

The cropping area (ft2) of the three greenhouse size options presented in this section are as follows :

TOTAL AREA OF GREENHOUSE	TOMATO	CUCUMBER	LETTUCE
7,500 ft2 ..	3,000	1,500	3,000
10,000 ft2 ..	4,000	2,000	4,000
30,000 ft2 ..	10,000	10,000	10,000

NOTE: Estimates do not include installation costs of the growing and lighting systems.

TABLE 15. Capital costs for NFT hydroponic systems in Iqaluit greenhouse. (Closed System)

NFT HYDROPONIC CULTURE	TOMATO	CUCUMBER	LETTUCE
BASE COSTS ((\$) all greenhouse sizes up to 10,000 ft2/crop)			
Nutrient Mixing and Injection System (1)	&,275	6,275	6,275
Main Reservoir (500 gal)	890	890	890
Nutrient Concentrate Tanks (2 x 300 gal}	1,200	1,200	1,200
pH and EC Meters (2)	230	230	230
Propagation Room	4,000	2,(x@	---
Shipping Charges (3)	3, 000	3,000	3,000
TOTAL BASE CAPITAL COST	15,595	13,595	11.595
AREA COSTS (\$/ft2)			
- Nutrient Delivery System	0.08	0.08	0.08
- Plant Support and Nutrient Recovery System	1.05	1.05	1.35
- Shipping Charges	0.75	0.75	0.75
TOTAL AREA COST 7,500 ft2 ...	5,640	2,820	6,540
10,000 ft2 ...	7,520	3,760	8,720
30,000 ft2 ...	18,800	18,800	21,800
TOTAL CAPITAL COST FOR NFT GREENHOUSE			
7,500 ft2 ---	21.235	16,415	18,135
(\$/ft2)	7.08	10.94	6.05
10,000 ft2 . . .	23, 115	17,355	20,3 15
(\$/ft2)	5.78	8.68	5.08
30,000 ft2 ...	34,395	32,395	33,395
(\$/ft2)	3.44	3.24	3.34

(*) See explanatory notes on page 73.

TABLE 16 **Capital costs for peat bag or rockwool culture in Iqaluit** greenhouse. (Closed System)

PEAT BAG / ROCKWOOL CULTURE (CLOSED SYSTEM)	TOMATO	CUCUMBER
BASE COSTS (($) all greenhouse sizes up to 10,000 ft2/crop)		
Nutrient Mixing and Injection System (1)	6, 275	6,275
Main Reservoir (500 gal)	890	890
Nutrient Concentrate Tanks (2 x 300 gal)	1,200	1,200
pH and EC Meters (2)	230	230
Propagation Room	4,0 00	2,000
Shipping Charges (3)	3,000	3,000
TOTAL BASE CAPITAL COST	15,595	13,595
AREA COSTS ($/ft2)		
- Nutrient Delivery System	0.40	0.40
- Plant Support and Nutrient Recovery System	1.05	1.05
- Shipping Charges	0.75	0.75
TOTAL AREA COST 7,500 ft2 ...	6,600	3,300
10,000 ft2 ...	8,800	4,400
30,000 ft2 ...	22,000	22,000
TOTAL CAPITAL COST FOR PEAT BAG / ROCKWOOL GREENHOUSE		
7,500 ft2 . . .	22, 195	16,895
($/ft2)	7.40	11.26
10,000 ft2 ...	24,395	17,995
($/ft2)	6.10	9.00
3(3, 000ft2...	37,595	35,595
($/ft2)	3.76	3.56

(*) See explanatory notes on page 73.

TABLE 17 Capital costs for peat bag or rockwool culture *in* Iqaluit greenhouse. (Open System)

PEAT BAG / ROCKWOOL CULTURE (OPEN SYSTEM)	TOMATO	CUCUMBER
BASE COSTS (($) all greenhouse sizes up to 10, 000 ft2/crop		
Nutrient Mixing and Injection System (1)	6,275	6,275
Main Reservoir (500 gal)	890	890
Nutrient Concentrate Tanks (2 x 300 gal)	1,200	1,200
Discarded Solution Holding Tank (1000 gal) (4)	750	750
pH and EC Meters (2)	23(-j	230
Propagation Room	4,000	2,000
Shipping Charges (3)	4 , 000	4, 000
TOTAL BASE CAPITAL COST	17,345	15,345
AREA COSTS ($/ft2)		
- Nutrient Delivery System	0.40	0.40
- Plant Support and Nutrient Recovery System	1.05	1.05
- Shipping Charges	0. 7.5	0.75
TOTAL AREA COST 7,500 ft2 ...	6,600	3,300
10,000 ft2 ...	8,800	4,400
30,000 ft2 ...	22,000	22,000
TOTAL CAPITAL COST FOR PEAT BAG / ROCKWOOL GREENHOUSE		
7,500 ft2 ...	23,945	18,645
($/ft2)	7.98	12.43
ii>, 000 ft2 . . .	26,145	15',74s
($/ft2)	6.54	9.87
30,000 ft2 ...	39,345	37,345
($/ft2)	3.93	3.73

(*) See explanatory notes on page 73.

NOTES for **Tables 15, 16 and 17**

(1) Nutrient mixers and injection systems are designed to allow future expansion to 10,000 ft2 of growing area per crop. (Hence the estimates for maximum size of 30,000 ft2)

(2) These meters are used interchangeably for all three crops and will be split 3 ways (Total Cost $ o90)

(3) The complete package for a 10, 000 ft2 greenhouse can be accommodated in one 20 foot container. The tanks will have to be shipped separately.

Local materials may be substituted for sever-al of the required items:

1. Local storage or septic tanks may be substituted for mixing reservoi r-s and smaller tanks could replace nutrient concentrate containers.

2. The trough support system required for the culture of NFT lettuce may be produced from locally available materials. Troughs however should be purchased from a supplier.

3. For tomatoes and" cucumbers? a support system similar to the one described in Section 4 may also be constructed from local materials.

No costs have been provided for the Main Reservoir heating system (Stainless coils and thermostat control). Also an Ultra-Violet water sterilizing unit may be required to kill micro-organisms (estimated $ 2,500 / crop).

TABLE 17 : The cost of the holding tank required for an open system is split evenly between the tomato and cucumber crops. Additional Shipping costs of $ 1,000 have also been estimated for this requirement.

TABLE 19 Combined capital costs for different greenhouse size options. (Total of growing system and CO2/ lighting system costs.

	7,500 ft2	10,000 ft2	30,000 ft2
TOMATO/CUCUMBER and LETTUCE in NFT SYSTEM	94,110 12.55/ft2	107,885 10.79/ft2	216,120 7.20/ft2
TOMATO/CUCUMBER in PEAT/ROCKWOOL CLOSED SYSTEM LETTUCE in NFT SYSTEM	95,550 12.74/ft2	109,805 10.98/ft2	222,520 7.42/ft 2
TOMATO/CUCUMBER in PEAT/ROCKWOOL OPEN SYSTEM LETTUCE in NFT SYSTEM	99,050 13.21/ft2	113,305 11.33/ft 2	226,020 7.53/ft2

As Table 19 illustrates, the capital costs per unit area ($/ft2 growing area) decrease dramatically as the scale of the greenhouse increases. This is due to the large base investment in equipment required of all greenhouses regardless of size. The best economy in this case would be a 30,000 ft2 greenhouse. Currently in Ontario, it costs between $ 5.00 and $ 6.00 /ft2 to outfit an existing greenhouse with NFT growing systems and artificial lighting. This compares favourably with our estimate of $ 7.50/ft2 for a northern greenhouse of 30,000 ft2 and somewhat less favourably to operations of a smaller scale ($ 11.00/ft2 for 10,000 ft2 of growing area)

Several options are present to reduce the capital costs of the proposed greenhouse. (1) the costs would be decreased further if only one crop were being grown (reduced base capital investment) instead of the proposed three crops. (2) Another alternative to reducing the costs would be to reduce the complement of artificial light fixtures and operate only on an 8 month schedule with maximal use of available lighting. This option would reduce capital costs by as much as 33% to 45%.

All three growing system options have similar capital costs with NFT systems being the least costly and peat or rockwool open system being the most expensive. We cannot therefore use the differences in capital costs as a means of selecting a preferred system. Selection will rather be made on the basis of annual operating costs and system suitability to northern conditions.

6.2 ANNUAL OPERATING COSTS

The major component= of the annual operating costs are as follows:

1. LABOUR AND MANAGEMENT
2. GROWING SUPPLIES AND EQUIPMENT
3. ELECTRIC POWER
4. WATER

Each of the above components will be estimated in the following tables.

LABOUR AND MANAGEMENT

The operation of a greenhouse requires a qualified horticulturalist and depending on the growing area, a number of full and part time assistants. The exact salary requirements cannot be properly assessed at this time, but the following estimates will be used: (It is assumed that the horticulturalist will be employed on a shared basis with some other enterprise)

HORTICULTURALIST	TOTAL OF ONE MAN-YEAR
PART-TIME HELP	

TOTAL LABOUR COSTS ..... $ 45, 000 / ANNUM

If we divide these figures in direct proportion to the growing area occupied by each of the three vegetables, we arrive at the following annual labour costs/crop :

TOMATO	40%	$ 18,000
CUCUMBER	20% ...-	$ 9,000
LETTUCE	40%	$ 18,000

The actual workload within the greenhouse will largely' be concentrated on the tomato and cucumber crops which are labour intensive and require constant pruning and training along supporting wires. In the lettuce house, less manpower is required, chiefly to set out seedlings and harvest plants.

GROWING SUPPLIES AND EQUIPMENT

The primary components of annual supply costs are the growing medium (peat, rockwool, plastic gro-tube), fertilizers/chemicals and the shipping charges associated with delivering them to the north. A number of assumptions were made when calculating these values.

(1) The 8 month growing season would have a total of 2 plantings of tomato and cucumber and year-round production would. have 3 plantings.

(2) Lettuce would complete 0.5 cycles at 4,000 plants/cycle.

(3) If peat bags or rockwool were used, the medium would only be replaced once over the year (regardless of season length).

In the case of peat bag culture, a separate price option was calculated for the use of local as well as imported medium. It is however important to note that the cost of collecting, transporting and processing local soil is not included and must be added to the estimate.

TABLE 20 Annual costs for growing supplies in greenhouse

[A] 8 MONTH OPERATION ($/year)

	TOMATO	CUCUMBER	LETTUCE	TOTAL
7,500 ft2				
NFT	1,650	465	355	2,470
PEAT BAG (IMPORTED)	2,940	1,265	" (*)	4.560
PEAT BAG (LOCAL) (#)	1,235	400	" (*)	1,990
ROCKWOOL	2,430	830	" (*)	3? 015
10,000 ft2				
NFT	2,210	620	475	3,305
PEAT BAG (IMPORTED)	3,920	1,685	" (*)	6,080
PEAT BAG (LOCAL)(#)	1,650	530	" (*)	2,655
ROCKWOOL	3.240	1,110	" (*)	4,825

(#) Excluding cost of peat collection? transport and preparation.
(*) Lettuce is in all cases grown on NFT growing SY=t=rn-

CB 1 12 MONTH L) PERAT I ON (S/year)

7,500 ft2	TOMATO	CUCUMBER	LETTUCE	TOTAL
N FT	2,275	665	530	3,470
PEAT BAG (IMPORTED)	3,560	1, 460	" (*)	5, 550
PEAT BAG (LOCAL) (#)	1,855	600	" (*)	2, 98S
ROCKWOOL	3,015	1,035	" (*)	4,580
10,000 ft2				
NFT	3,035	890	710	4,635
PEAT BAG (IMPORTED)	4,745	1,950	" (*)	7,405
PEAT BAG (LOCAL) (#)	2,475	795	" (*)	3,980
ROCKWOOL	4,020	1,380	" (*)	6,110

(#) Excluding cost of peat collection, transport and preparation.
(*) Lettuce is in all cases grown on NFT growing system.

ELECTRIC POWER

The cost of power is calculated solely using the power ratings of the HID lights in the three greenhouse rooms. Same other sources of power including pumps and miscellaneous equipment will not be included in this table. The cost is determined by:

TOTAL KILOWATTS × HOURS OF USE × RATE
(450W/lamp × # lamps (Tab 7)) (Tables 12-14) ($ 0.30 /kWhr)

TABLE 21 Annual cost of electrical power for lighting

7,500 ft2	TOMATO	CUCUMBER	LETTUCE	TOTAL
8 MONTHS	1,600	2,000	4,200	7,800
12 MONTHS	9,200	7,200	17,000	33,400
10,000 ft2				
8 MONTHS	2,100	2,700	5,600	10,400
12 MONTHS	12,100	10,000	22,700	44,800

WATER

The consumption of water by the plants is difficult to estimate. According to Dr. Cooper, a mature crop of tomatoes growing in closed NFT culture consumes an average of 2 litres/ plant/' day. In the following table, this value will be used to estimate annual requirements. A value of 0.2 litres/ plant/ day will be used for the lettuce crop. The costs. will be "split according to the relative consumption of water by each crop.

For the determination of costs and required volumes in an open hydroponic system, the values of the closed system will be tripled. (This is a conservative estimate and will need to be assessed more thoroughly when final designs are made)

TABLE 22 Annual volume (gal ions) of water required for closed hydroponic system.

[A] VOLUME OF WATER (gallons)

7,500 ft2	TOMATO	CUCUMBER	LETTUCE	TOTAL
NUMBER OF PLANTS	600	107	3,000	---
8 MONTHS	73,500	20,500	36,800	130,800
12 MONTHS	109,500	30,500	55,000	195,000
10,000 ft2				
NUMBER OF PLANTS	800	222	4, 000	---
8 MONTHS	98,000	27,000	49,000	174,200
12 MONTHS	146, 000	40, 500	73, 000	239,500

NOTE : Fur estimates of open system volumes, multi Fly the estimates above by a factor of 3.

TABLE 23 Annual cost of water in closed and open systems. (assuming water volume of open system = 3 x closed system)

[B] ANNUAL COST OF WATER (CLOSED SYSTEM)

	TOMATO	CUCUMBER	LETTUCE	TOTAL
7,500 ft2	56%	16%	28%	
8 MONTHS	650	200	350	1,200
12 MONTHS	975	300	525	1,800
10,000 ft2				
8 MONTHS	900	250	450	1,600
12 MONTHS	1,350	375	675	2,400

[B] ANNUAL COST OF WATER (OPEN SYSTEM)

	TOMATO	CUCUMBER	LETTUCE	TOTAL
7,500 ft2	56%	16%	28%	
8 MONTHS	2,200	600	350 (*)	3,150
12 MONTHS	3,300	900	525 (*)	4,725
10,000 ft2				
8 MONTHS	2,800	800	450 (*)	4,050
12 MONTHS	4,200	1,200	675 (*)	6,075

(*) Estimates are for lettuce grown an NFT closed system

TABLE 24 **Total** annual operating costs (horticultural and lighting) for different greenhouse scenarios.

GREENHOUSE SIZE :	7,500 ft2		10,000 ft2	
GROWING SEASON :	8 MONTH	12 MONTH	8 MONTH	12 MONTH
ALL CROPS NFT	56,470 7.53	83,670 11.16	60,305 6.03	96,835 9.68
LETTUCE NFT TOM/CUC PEAT CLOSED SYSTEM	58,560 7.81	85,750 11.43	63,080 6.31	99.605 ?.96
LETTUCE NFT TOM/CUC PEAT OPEN SYSTEM	60,510 8.07	88,675 11.82	65,530 6.55	103,280 10.33
LETTUCE NFT TOM/CUC ROCKWOOL CLOSED SYSTEM	57,615 7.68	84,780 11.30	61,825 6.18	98,310 9.83
LETTUCE NFT TOM/CUC ROCKWOOL OPEN SYSTEM	59,565 7.94	84,780 11.69	61,825 6.43	98,310 10.20

NOTE : It is important to remember that the above figures do not take into account annual costs for mechanical and structural maintenance.

It is apparent from the figures in Table 24 that there is no significant difference in operating costs between the growing systems examined (7% between NFT and open peat bag systems). A significant increase in operating costs is however incurred when the growing season is increased from 8 to 12 months (from 50% to 60% increase). This is largely due to the high lighting (and energy) requirements of the winter season (see Table 21).

The following two options will be used to assess the potential returns from a northern greenhouse. Other options may be also be evaluated using figures presented in Table 24.

TABLE 25 Cost/Benefit analysis of annual operating costs versus potential returns of different scenarios.

(A) OPERATING COSTS (HORTICULTURAL & LIGHTING)

		7,500 ft2	10,000 ft2
SCENARIO A :	ALL CROPS NFT SYSTEM	7,500 ft2	10,000 ft2
	LETTUCE 12 MONTHS	69,620	77, 865
	TOM/CUC 8 MONTHS	9.28	7.79
SCENARIO B :	ALL CROPS NFT SYSTEM	7,500 ft2	10,000 ft2
	ALL CROPS 12 MONTHS	83,670	96,835
		11.16	9.68

(B) POTENTIAL F'FJ)DUCTION RETURNS

	7,500 ft2	10,000 ft2
LETTUCE 12 MONTHS	(19,500 hd @ 3.86)	(26,000 hd @ 3.86)
TOMATO 8 MONTHS	(12,000 lb @ 2.14)	(16,000 lb @ 2.14)
CUCUMBER 8 MONTHS	(7,500 lb @ 1.40)	(10.000 lb @ 1.40)
TOTAL PROJECTED RETURN :	$ 111,450	$ 148,600
	----------($ 14.86 ft2)----------	
LETTUCE 12 MONTHS	(19,500 hd @ 3.86)	(26,000 hd @ 3.86)
TOMATO 12 MONTHS	(19,500 lb @ 2.14)	(20, 000 lb @ 2.14)
CUCUMBER 12 MONTHS	(12, 000 lb @ 1.40)	(16,000 lb @ 1.40)
TOTAL PROJECTED RETURN :	$ 153, 800	$ 178,4 00
	----------($ 17.84 ft2)----------	

See Table 4 for target yields and Table 2 for market value (S/lb)

- If seedless cucumbers are grown (@ 4.08 lb), total returns are increased by 18% to 24% depending on option select ea.

(C) COST / BENEFIT SUMMARY

		7,500 ft2	10,000 ft2
SCENARIO A	RETURN	14.86 ft2	14.86 ft2
LETTUCE 12 MONTHS	OF COST	9.28 ft2	7.79 ft2
TOM/CUC 8 MONTHS			
	DIFFERENCE (per annum)	5.58 ft2 ($ 41,850)	7.07 ft2 ($ 70,700)
SCENARIO B	RETURN	17.84 ft2	17.84 ft2
LETTUCE 12 MONTHS	OF COST	11.15 ft2	9.58 ft2
TOM/CUC 12 MONTHS			
	DIFFERENCE (per annum)	6.68 ft2 ($ 50,100)	8.16 ft2 ($ 81,600)
CAPITAL COSTS OF NFT GROWING SYSTEM		$ 94,110	$ 107,885

In both scenarios, the potential returns are greater for the larger greenhouse surface. A 62% (B) to 68% (A) increase in production returns are obtained from a 33% increase in growing surface (7,500 to 10,000 ft2). Despite higher operating costs, year-round production of all three vegetables would appear to be economically attractive (providing horticultural feasibility is established).

A more complete economic picture cannot be presented without the remainder of the capital cost (structural and mechanical). It does however appear that either production scenario will prove economical to the prospective operator.

RECOMMENDATIONS

NFT hydroponic culture is recommended as the most practical growing system for initial trials **in the Iqaluit greenhouse.**

- least expensive of all potential systems (capital as well as annual costs)
- no importation of media required and no problem with disposal of used media.
- same degree of horticultural expertise required for all three systems evaluated.
- being a closed system, permits water conservation and elimination of disposal problems anticipated with open systems.
- is easily convertible to peat bag or rock-wool culture.

An initial cultivation area of 10,000 ft2 is recommended to ensure the best return on investment possible. Serious **consideration** should be given to future expansion to meet local vegetable market demand.

An **initial cultivation period of 8 months for tomato** and cucumber plants and 12 months for lettuce is **recommended- Once sufficient** experience **has been** acquired with the cultivation of these crops, a year-round schedule should be attempted to maintain a steady supply of produce for the local market.

The acquisition of **a** competent horticulturalist to manage the proposed facility **is essential to the success of the operation. Graduates from the University of Laval,** Ste Foy, Quebec and the University of Guelph, , Ontario would **be likely candidates** although **persons should ideally have previous working experience with hydroponic vegetable cultivation.**

APPENDIX A

SUPPLIERS OF EQUIPMENT AND SUPPORT ORGANIZATIONS

COMPANY	PRODUCTS/SERVICE
AGRO DYNAMICS INC. Building 3, Navy Yard Brooklyn, N.Y. 11205 USA 1-800-AGRO-CAN	Greenhouse Computer systems Grodan tm Rockwool systems
AMERICAN GREENHOUSE SYSTEMS INC. 110 Half Acre Lane Panama City Beach Florida 32407	Supplier of complete hydroponic greenhouses and training for new growers
BALL-SUPERIOR LTD. 1155 Birchview Drive Mississauga, Ontario L5H 3E1 (416) 278-5201	Greenhouse supplies and equipment
CANADIAN HYDROGARDENS LIMITED 411 Book Road West Ancaster, Ontario L9G 3L1 (416) 648-1801 John Stevens	Complete hydroponic systems and all required equipment. Fertilizers, meters, tanks Water, tissue and solution analysis and interpretation Grower Support
CANADIAN HYDROPHYTE SYSTEMS 3002 Sandlewood Court Burlington, Ontario L7M 2A4 (416) 335-3093	NFT lettuce trough system Rockwool
GROWERS TECHNICAL SERVICES 2241 Dunwin Drive, Erin Mills Mississauga, Ontario L5L 1A3 (416) 828-5925 Alex Turkewitsch	Fertilizer injection systems DGT Computer controllers pH and EC meters. Ebb and Flow benching systems

COMPANY	PRODUCTS/SERVICE
LES INDUSTRIES HARNOIS INC. 1044 rue Principale, St-Thomas-de-Joliette Quebec J0K 3L0 (514) 756-1041 Jean Lamoureux	Design and supply of hydroponic equipment and lighting fixtures. Fertilizer mixers, rockwool, NFT gutters and support structures. Greenhouse structures.
Horticultural Research Institute of Ontario Ontario Ministry of Agriculture and Food Vineland Station, Ontario L0R 2E0 (416) 582-4141	Information on hydroponic culture and suitable vegetable varieties
HYDROCULTURE, INC. 99th ave. and West Glendale P.O. Box 1655 Glendale, Arizona 85311 USA	Supplier of equipment and training for hydroponic growers.
HYDRO-GARDENS, INC P.O. Box 9707 Colorado Springs, Colorado 80932 USA (303) 495-2266	Complete hydroponic systems and all required equipment and supplies. Custom blends of fertilizer, peat bags, NFT lettuce growing system
Hydroponic Society of America P.O. box 516, Brentwood, California 94513 USA	Society for soilless growers Information and membership.
ISOSC (The International Society for Soilless Culture) Secretariat of ISOSC P.O. Box 52, Wageningen, The Netherlands	Worldwide society for the promotion of soilless culture Information center for soilless culture.
JACK VAN KLAVEREN LTD. P.O. Box 910 St Catharines, Ontario L2R 6Z4 (416) 684-1103	Greenhouse supplies

COMPANY	PRODUCTS/SERVICE
LETTUCE FROM EDEN R.R. 1 Cargill, Ontario N0G 1J0 (519) .360 -95'==	-Hydroponic supplies and consulting
METEX Corporation Limited 12 Fenn Drive, Unit 1 Weston, Ontario M9L 2A9 (416) 749-1210 John Pudney	Fertilizer injection systems pH and EC meters, pumps
W.H. PERRON & CO. LTD 515 Labelle Blvd. Laval, Quebec H7V 2T3 (514) 332-3610	Greenhouse supplies and equipment, fertilizers, seeds
PL LIGHT SYSTEMS CANADA INC. P.O. Box 206 183 South Service rd., Unit 2 Grimsby, Ontario L3M 4G3 (416) 945-4133	Greenhouse lighting equipment Lighting design for different crops
PLANT PRODUCTS CO. LTD 314 Orenda Road, Brampton, Ontario L6T 1G1 (416) 793-7000	Pargro rockwool, fertilizers greenhouse equipment and pesticides/fungicides
PREMIER PEAT MOSS LTD. P.O. Box 520 Chemin Temiscouata Riviere-du-Loup, Quebec G5R 3Z1 (418) 862-3964	Soilless growing mixes
PRIVA COMPUTERS INC. 183 South Service Road Grimsby, Ontario L3M 4H7	Greenhouse computers and CO2 generators
SHAMROCK INDUSTRIES Hwy 59 South Norwich, Ontario N0J 1P0 (519) 863-3024	Speedel tm. gro bags /blended peat mixes for tomato and cucumber production

COMPANY	PRODUCTS / SERVICE
SMITHERS-OASIS CANADA LTD 108 McMaster Avenue Ajax, Ontario L1S 2E7	Oasis tm growing media
STOKES SEEDS LTD. P.O. Box 10, 39 James street St Catharines, Ontario L2R 6R6 (416) 688-43(10	Vegetable seeds
VARY INDUSTRIES (1982) LTD 317 South Service Road W. Grimsby, Ontario L3M 4N6 (416) 945-9691	Greenhouse structures Bench and support systems
PETER ZWART AND ASSOCIATES 178 Alway Road P.O. Box 235, Grimsby Ontario L3M 4G3 (416) 643-4156 John Knight	Fertilizer mixing systems Hydroponic systems and equipment.

APPENDIX B

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ENGINEERING DESIGN, CAPITAL AND OPERATING COST ESTIMATES

Iqaluit Greenhouse Feasibility Study

for

The Department of Economic Development and Tourism
Government of the Northwest Territories
Iqaluit, N.W.T.

by

Burdett-Moulton Architects & Engineers Limited

September, 1988

TABLE OF CONTENTS

1. INTRODUCTION

The purpose of this study is to research and develop an economical greenhouse design for Iqaluit with associated capital and operating rests. Specifically the work involved includes:

- Based on climatic conditions, energy conservation requirementts, the crops, and costs, an investigation was performed of greenhouse systems available to determine which would be most appropriate. Diagrams and a description of the recommended system with necessary adaptations are presented.

- Based on information provided by greenhouse suppliers and local contractors, the capital costs of the greenhouse were estimated.

- Based on energy costs, supplies and labour, the operating expenses were estimated. Using the information gathered in the market study, the income of the greenhouse was also estimated.

- Through a consultation program with other northern greenhouse operators, a review of the design was undertaken to solicit input and options.

- Potential funding sources were identified.

2. GREENHOUSE DESIGN

Various types of greenhouses were considered with the prime requirement being availability from a comme rcial greenhouse supplier. Illustrations of the types of systems and the rationale utilized in deterrnining which is the most suitable follows.

Figure 1 indicates a design developed by the Brace Institute, that appears to provide a sensible approach for the north because there is minimum heat loss. Assuming a significant solar contribution from March to October, for our latitude the best angle of glazing for the south facing glazing is about 50°. This is only an approximation because data was extrapolated from Churchill, Manitoba and Edmonton, Alberta (see Appendix A) .

Upon further investigation (again using Churchill data, see Appendix B), it was determined that, for the eight month growing season, an Iqaluit greenhouse would obtain approximately 32% of its light through northern

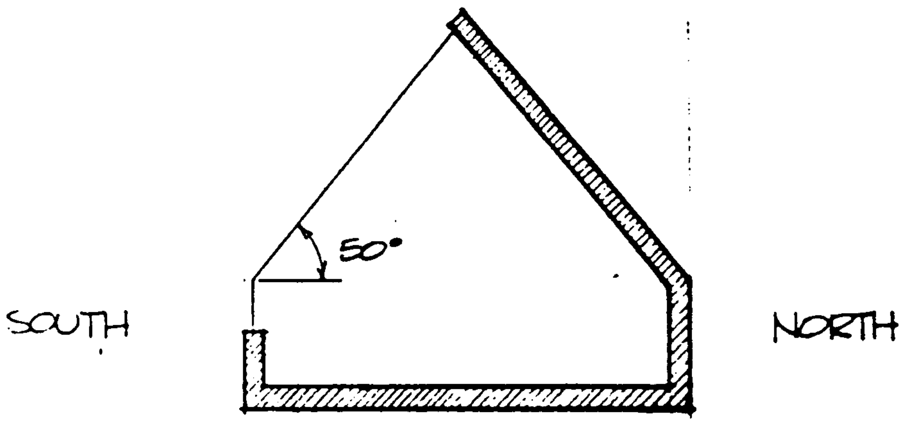


FIGURE 1

glazing. This results because there is nearly 24 hours of sunlight during the summer. Without northern glazing the rate of plant growth would be significantly reduced. This fact was verified with the Agricultural and Forestry Experiment Station of the University of Alaska in Fairbanks. For this reason, this design was not considered further.

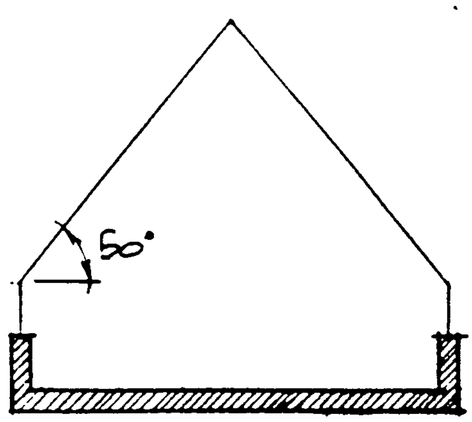


FIGURE 2

Figure 2 illustrates a type of greenhouse that could be used but a quick assessment indicated that the similar style of greenhouse, shown in figure 3, is more practical.

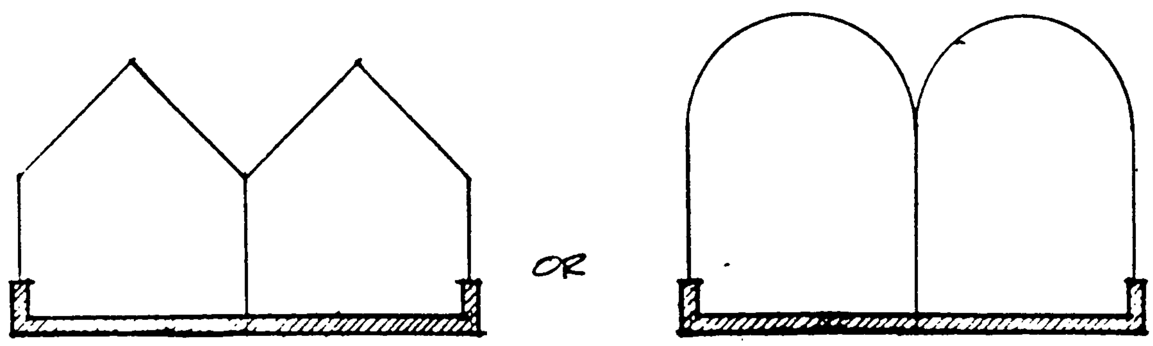


FIGURE 3

Greenhouses such as these are capable of withstanding strong northern winds, are inexpensive to construct, and have a low heat loss per square foot of growing area. Internal clear partitions can be installed to provide different environmental areas to meet different crop requirements.

The next issue involves the kind of glazing to be used. Due to our extreme climate (17,852 OF degree days per year) , only double glazing was seriously considered. There are three types readily available from commercial greenhouse suppliers; that is, double acrylic, double polycarbonate and double polyethylene. Double acrylic or polycarbonate are desirable because they have such a high resistance to impact, but they are both expensive. Double polyethylene is least expensive, but there were concerns with whether it would withstand Iqaluit 's high winds at temperatures of -40 OF. In conversation with greenhouse growers and suppliers, no problems of this nature have been reported. One layer of polyethylene would have to be replaced every two or three years but the other layer would remain intact and the crops would be protected.

To optimize both capital and operating costs while at the same time providing a functional and structurally sound greenhouse it was determined that a multi span greenhouse with walls of double acrylic and a roof of double polyethylene would be the most feasible. The bottom two feet of the walls, (below the level of the growing benches) , are to be insulated.

The best type of floor would be raised on spread footings or piles. This would eliminate any degradation of the permafrost and subsequent shifting of the foundation, as well as prevent snowdrifting around the structure.

Unfortunately, this foundations system is also the most expensive. To reduce costs , estimates are based on a foundation system that consists of a grade beam and a gravel floor placed over 4 inches of polyurethane insulation. It has been verified that potential movement of the floor can be accommodated by the structure. The building will be oriented to minimize snowdrifting but some snow clearing will undoubtedly be required on the south side to ensure maximum solar radiation through the vertical glazing.

Figures 4, 5, 6 and 7 illustrate a greenhouse complex designed for Iqaluit. With this design, it will be possible to produce areasonably economical product in an environment that is constructed to withstand the harsh Arctic climate.

3. SITING ANALYSIS

As shorn in Figure 5, the site on the east side of the road to the power plant provides the most suitable location for the greenhouse. Development costs for this site would be expensive because long lengths of piping are required for the installation of the heat recovery system and for connection to the town's water supply system. The site, however, is reasonably level for construction of buildings and access roads. Access to this site, both for construction and transporting produce, is good. There is ample area to locate the greenhouse with proper southern orientation, to allow for future expansion, and to provide parking.

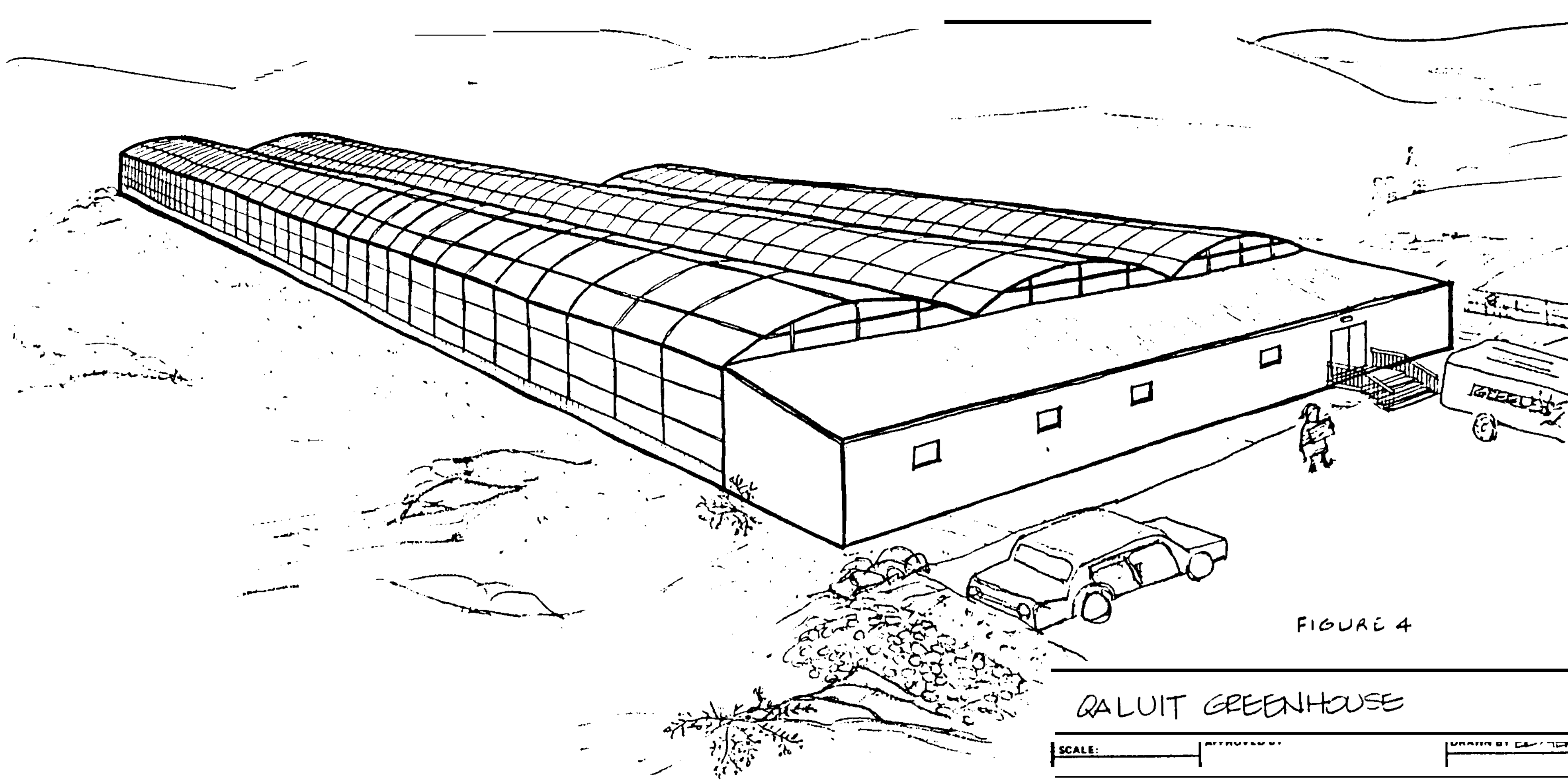
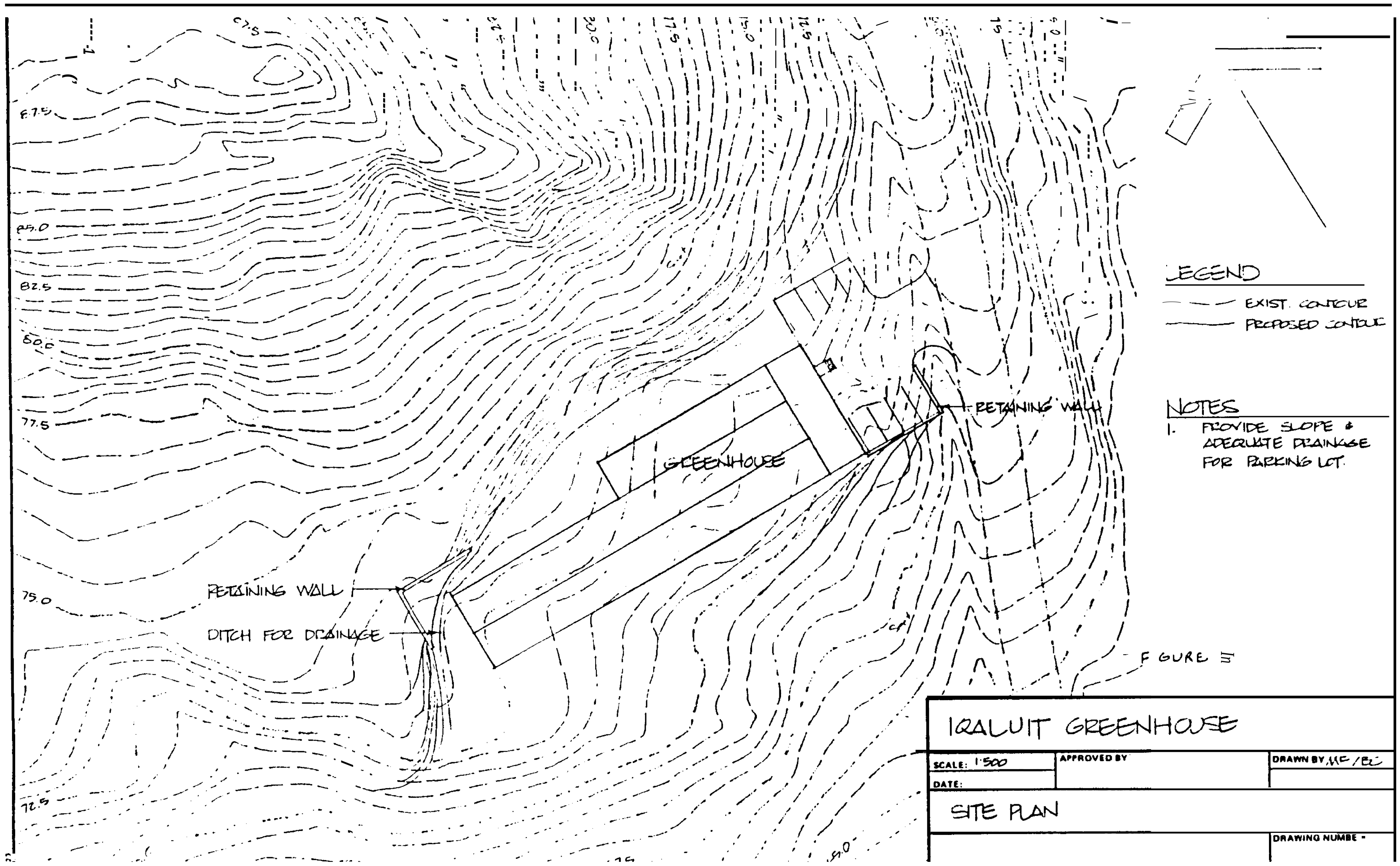


FIGURE 4

QALUIT GREENHOUSE

SCALE:

PERSPECTIVE


LEGEND
EXIST. CONTOUR
PROPOSED CONTOUR
NOTES
1. PROVIDE SLOPE & ADEQUATE DRAINAGE FOR PARKING LOT.
RETAINING WALL
GREENHOUSE
RETAINING WALL
DITCH FOR DRAINAGE
FIGURE 5
IQALUIT GREENHOUSE
SCALE: 1:500
APPROVED BY
DRAWN BY: MF / BL
DATE:
SITE PLAN
DRAWING NUMBER
67.5
85.0
82.5
80.0
77.5
75.0
72.5

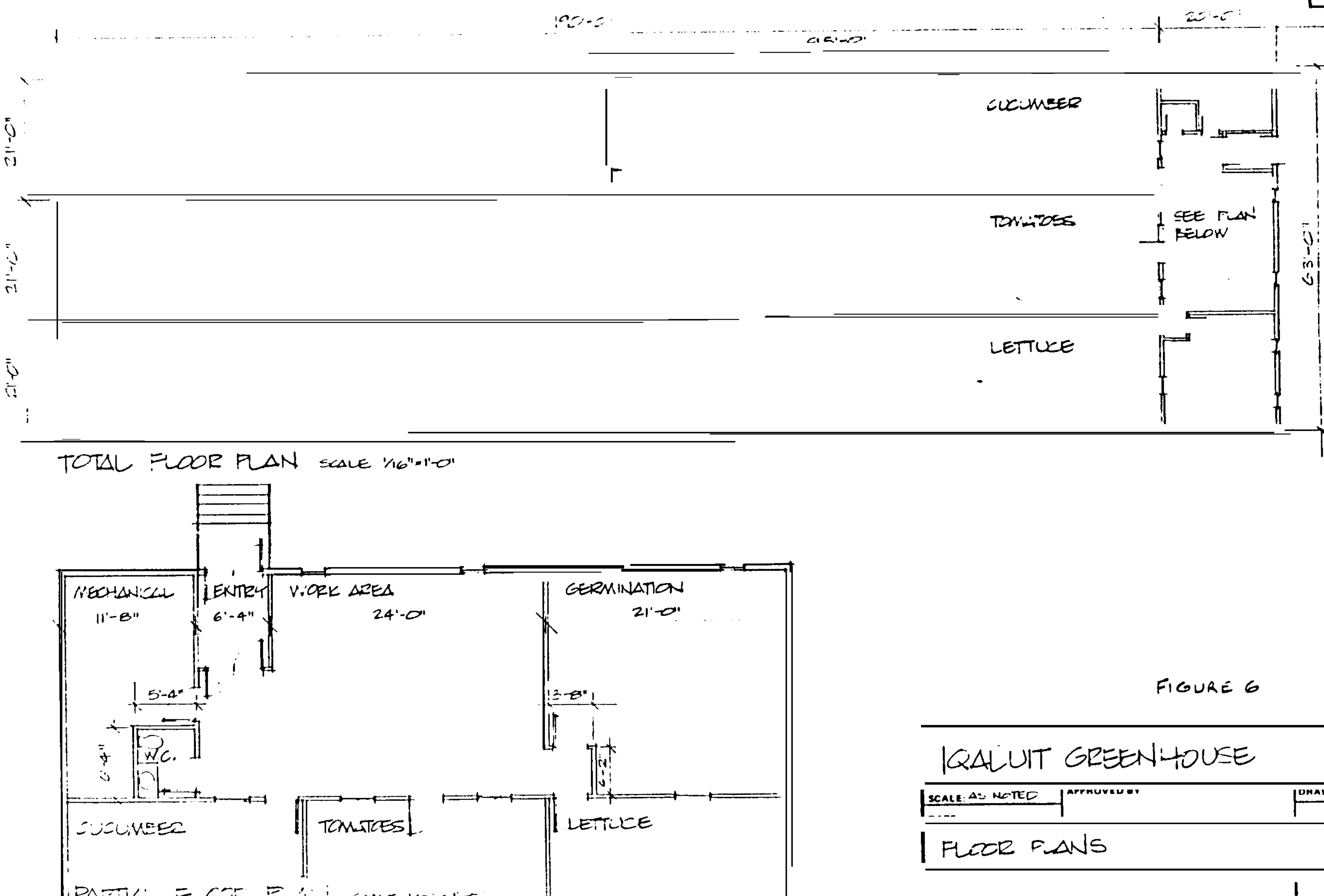
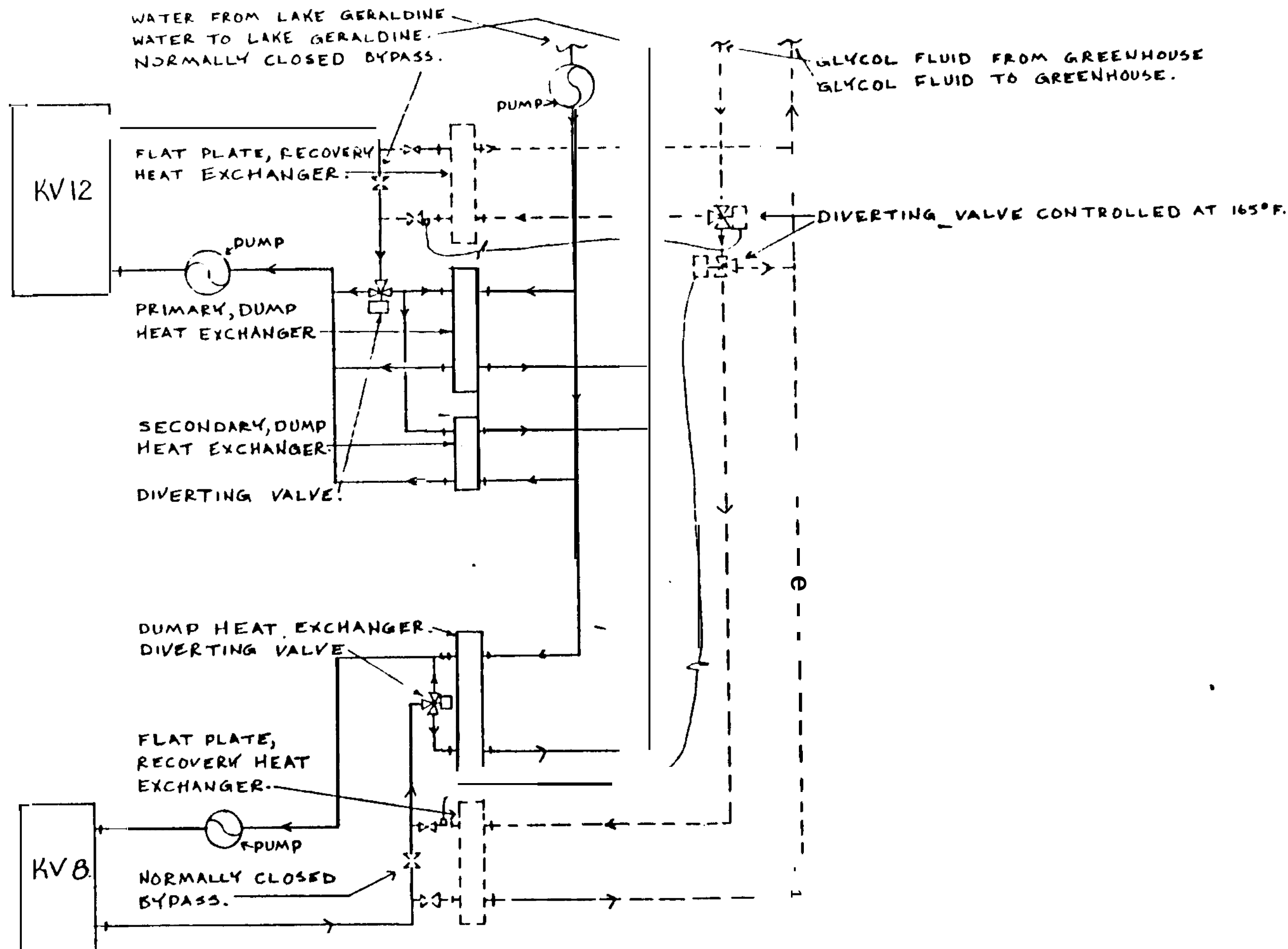


FIGURE 6

IQALUIT GREENHOUSE

SCALE: AS NOTED | APPROVED BY | DRAWN BY DC

FLOOR PLANS



PROPOSED JACKET WATER
HEAT RECOVERY FLOW
DIAGRAM FOR IQALUIT N.W.T.

——— EXISTING
- - - - - PROPOSED

IQALUIT G

SCALE: NTS | APPROVED BY
DATE:

BURDETT-MOULTON
ARCHITECTS & ENGINEE
P.O. Box 631
IQALUIT (FROBISHER BAY) N.W.T.
(819) 979-6539

4. CAPITAL COSTS AND OPERATING INCOME AND COSTS

In attempting to optimize a greenhouse operation, a number of variables have been investigated. Some of these are dealt with in the previous study "Horticultural Design and Production Scenarios". The greenhouse size and the duration of the growing season each have a significant impact on costs. Provided in this report are capital and operating cost estimates for the 7,500 ft^2 and 10,000 ft^2 sizes, and 8 month and 12 month growing seasons outlined in the previous horticultural report.

The duration of the growing season has a serious impact on the heating system. As indicated in Appendix C, the approximate heating costs for a sample 10,000 square foot greenhouse (not including the header house) for an eight month growing season is $28,800 as compared with $65,300 for a twelve month growing season. The cost of a heat recovery system from the N.C.P.C. power plant is estimated at $119,000 (see Table I). Obviously a heat recovery system has a very quick economic payback based on a 12 month growing season but it may be questionable with an 8 month growing season.

The feasibility of the greenhouse with and without waste heat recovery will be considered in the economic analysis.

Retailers have indicated that the wholesale price is approximately 75% of the retail price. With air freight, the cost of produce from southern suppliers for businesses and institutions is approximately equal to the local retail price. The marketing study also indicates that buyers are prepared to pay a 15% premium for good quality locally grown produce. Assuming that 50% of the produce will be sold to institutions and businesses, and 50% to local retailers, the average anticipated selling price was calculated in the following manner:

$$\text{average selling price} = \frac{\text{market price to retailers} + \text{market price to businesses and institutions}}{2}$$

$$= \frac{\text{market price} \times (100\% - 25\% + 15\%) + \text{market price} \times (100\% + 15\%)}{2}$$

$$= \frac{\text{market price} \times 90\% + \text{market price} \times 115\%}{2}$$

$$= \text{market price} \times 102.5\%$$

Therefore the market prices indicated in the market study will be used as the average selling prices in the income projection.

The following tables indicate capital costs and operating incomes and costs of various greenhouse scenarios. As shown in the tables when oil is used for heating, there is little difference between the income and the operating costs or that there is a deficit. It should be noted that capital debt repayment and interest payments have not been included in the operation tables.

TABLE I

CAPITAL COSTS FOR GREENHOUSE COMPLEX

	Item	7,500 sq.ft.	10,000 sq.ft.
1.	Heat Exchangers, etc. @ NCPC	$ 9,000	$ 9,000
2.	Exterior Heat Recovery Pipeline	42,000	42,000
3.	Mounting & Protection of Pipeline	20,000	20,000
4.	Freight for items 1,2,3	5,000	5,000
5.	Installation for items 1,2,3	25,000	25,000
6.	Site Preparation (level, grade)	1,500	2,000
7.	Structure Foundation	3,000	4,000
8.	Insulation & Material for Floor	26,100	34,800
9.	Packaged Greenhouse including Structure, Hardware, Doors, Walls , and Roof	40,900	54,500
10.	Freight for item 9	3,500	5,000
11.	Installation for item 9	10,000	13,000
12.	Greenhouse Ventilation	7,800	10,400
13.	Greenhouse Heating	29,900	37,500
14.	Tomato Shading Curtain	8,300	11,000
15.	Greenhouse NFT Hydroponic System	55,800	60,800
16.	Greenhouse Lighting	26,300	35,100
17.	Freight for items 12,13,14	2,000	2,000
18.	Installation for items 12,13,14,15,16	21,000	27,000
19.	CO_2 Generators	12,000	12,000
20.	Header House (1,260ft Z @ $80/ft^2)	100,800	100,800
21.	Emergency Generator	5,000	5,000
22.	Additional Mech/Elect. Greenhouse Costs in Header House	8,000	8,000
23.	Small Tools & Produce Containers	4,500	5,500
24.	Contingency at 5%	25,600	28,700
25.	Engineering at 7%	37,000	42,200
	Total	$530,000	$600,300

Deletion of Waste Heat System

	7,500 sq.ft.	10,000 sq.ft.
Delete Items 1,2,3,4,5 and Adjust Items 24,25	($119,000)	($119,000)
Total	$411,000	$481,300

TABLE II

INCOME AND EXPENSES-OPERATION FOR TWELVE MONTHS

Item	7,500 sq.ft.	10,000 sq.ft.
INCOME		
Lettuce ($3.44 per head)	$67,080	$89,440
Tomato ($2.14 per lb)	41,730	55,640
Cucumber ($1.49 per lb)	17,880	23,840
Total Income	$126,690	$168,920
EXPENSES		
Direct		
Labour	$45,000	$45,000
Growing Supplies & Equipment	3,470	4,635
Operating Overheads (Using Waste Heat)		
Electric power (Lights +3 H.P. Circulator)	$39,280	$50,680
Water	1,800	2,400
Oil	0	0
Repairs &Maintenance	3,000	3,600
Miscellaneous	1,200	1,500
Administrative Overheads		
Accounting & Legal	1,000	1,000
Insurance	2,600	3,500
Office Costs	900	1,200
Communications	1,100	1,500
Taxes	3,500	3,500
Total Expenses	$102,850	$118,515

TABLE III

INCOME AND EXPENSES-OPERATION FROM MARCH 1 TO OCTOBER 30

Item	7,500 sq. ft.	10,000 sq. ft.
INCOME		
Lettuce ($3.44 per head)	$41,280	$55,040
Tomato ($2. 14 per lb.)	25,680	34,240
Cucumber ($1 .49 per lb.)	11,175	14,900
Total Income	$78,135	$104,108
EXPENSES		
Direct		
Labour	$45,000	$45,000
Growing Supplies & Equipment	2,470	3,305
Operating Overhead (Using Waste Heat)		
Electric Power (Lights +3 H.P. Circulator)	$11,410	$14,010
Water	1,200	1,600
Oil	0	0
Repairs & Maintenance	2,000	2, 500
Miscellaneous	800	1,000
Administrative Overhead		
Accounting & Legal	1,000	1,000
Insurance	2,600	3,500
Office Costs	600	800
Communications	750	1,000
Taxes	3,500	3,500
Total Expenses	$71,230	$'77 ,215
Deletion of Waste Heat System		
Add Oil	$22,200	$29,600
Delete 3 H.P. circulator	(3, 610)	(3 ,610)
Total Expenses	$89 ,920	$103,205

TABLE IV

INCOME AND EXPENSES- OPERATION LETTUCE FOR TWELVE MONTHS AND TOMATOES AND CUCUMBER FROM MARCH 1 TO OCTOBER 30

Item	7,500 sq. ft.	10,000 sq. ft.
INCOME		
Lettuce ($3. 44 per head)	$67,080	$89,440
Tomato ($2. 14 per lb.)	25,680	34,240
Cucumber ($1.49 per lb.)	11,175	14,900
Total Income	$103,935	$138,580
EXPENSES		
Direct		
Labour	$45,000	$45,000
Growing Supplies & Equipment	2,645	3,540
Operating Overheads (Using Waste Heat)		
Electric Power (Lights +3 H.P. Circulator)	$26,500	$33,400
Water	1,375	1,825
Oil	0	0
Repairs & Maintenance	2,400	2,900
Miscellaneous	1,000	1,200
Administrative Overheads		
Accounting & Legal	1,000	1,000
Insurance	2,600	3,500
Office costs	700	1,000
Communications	900	1,200
Taxes	3,500	3,500
Total Expenses	$87 ,620	$98,065
Deletion of Waste Heat System		
Add Oil	$33,500	$44,600
Delete 3 H.P. Circulator	(5 ,900)	(5, 900)
Total Expenses	$115,220	$136,765

5. SUMMARY

Sunlight from a northerly direction should be considered in the design of the greenhouse for Iqaluit. A multispan greenhouse with double glazed acrylic walls, double glazed polyethylene roof and gravel floor provides an economical greenhouse system. The site on the east side of the road to the power plant provides the most suitable location.

The suggestions and observations of experience northern greenhouse operators are summarized in Appendix D of" this report. The most significant recommendation is that, since tomatoes and cucumber do not grow well under artificial light, they should be grown only during eight months of the year.

A list of potential funding sources for this project is located in Appendix E.

Based on the design, capital and operating cost and recommendations of northern greenhouse operators, proforma financial statements should be produced for the following options:

	Greenhouse Size	Growing Season	Status of Waste Heat Recovery System
Option 1 -	7,500 ft^2	8 month season	waste heat recovery system
Option 2 -	7,500 ft^2	8 month season	no waste heat recovery system
Option 3 -	7,500 ft^2	* 8/12 month season	waste heat recovery system
Option 4-	7,500 ft^2	* 8/12 month season	no waste heat recovery system
Option 5 -	10,000 ft^2	8 month season	waste heat recovery system
Option 6 -	10,000 ft^2	8 month season	no waste heat recovery system
Option ? -	10,000 ft^2	* 811: month season	waste heat recovery system
Option 8 -	10,000 ft^2	* 8/12 month season	no waste heat recovery system

* 8 months tomatoes and cucumbers and 12 months lettuce

APPENDIX A

ESTIMATE OF OPTIMUM ANGLE FOR SOUTH FACING GLAZING

The information for Edmonton and Churchill was taken from "An Analysis of Solar Radiation Data for Selected Locations in Canada" by J .E . Hay.

The optimum southward facing glazing angles for Edmonton, Alberta and Churchill, Manitoba from March to October are:

	Edmonton	Churchill
March	60°	70°
April		50°
May		300
June	20 0	20 o
July		300
August		40°
September	50°	50°
October		70°
		360 / 8 = 450

The latitudes for Edmonton, Churchill, and Iqaluit are 53034, 58045, and 63°45' respectively. The difference between Churchill and Edmonton is 5011 and between Iqaluit and Churchill is 5°0'. Therefore, if we extrapolate from Edmonton to Churchill to Iqaluit, the best angle of glazing for a south facing wall in Iqaluit is about 50°.

It is understood that this methodology does not take into account such things as variations in cloud cover, but should be sufficiently accurate.

APPENDIX B

ESTIMATE OF PERCENTAGE OF DAILY SOLAR RADIATION FROM THE NORTH

Again from "An Analysis of Solar Radiation Data for Selected Locations in Canada" by J.E. Hay, the mean monthly values of daily shortwave radiations on inclined surfaces for Churchill, Manitoba (in MJ/m² per day) are:

	March North	March South	April North	April South	May North	May South	June North	June South
10°	9.69	14.83	17.06	21.54	19.35	22.12	21.03	22.98
20°	6.95	17.04	14.39	23.23	17.35	22.91	19.33	23.31
30°	4.53	18.91	11.52	24.52	15.01	23.18	17.34	23.19
40°	4.16	20.39	8.52	25.29	12.38	22.95	14.94	22.55
50°	3.84	21.44	7.29	25.53	9.56	22.28	12.27	21.50
60°	3.59	22.02	6.80	25.23	8.11	21.11	10.03	20.01
70°	3.41	22.12	6.44	24.39	7.25	19.48	8.86	18.09
80°	3.56	21.73	6.14	23.05	6.53	17.44	7.86	15.88
90°	4.05	20.87	6.39	21.33	5.87	15.18	7.04	13.47

	July North	July South	August North	August South	September North	September South	October North	October South
10°	19.55	21.60	14.50	17.27	7.82	10.39	3.37	5.26
20°	17.92	22.07	12.69	18.17	6.30	11.36	2.45	6.10
30°	15.93	22.08	10.63	18.65	4.68	12.08	2.09	6.82
40°	13.62	21.59	8.39	18.76	3.65	12.53	1.82	7.38
50°	11.07	20.73	6.57	18.45	3.21	12.69	1.55	7.77
60°	9.26	19.41	5.81	17.71	2.79	12.57	1.29	7.98
70°	8.27	17.68	5.22	16.57	2.39	12.15	1.04	8.00
80°	7.42	15.61	4.68	15.06	2.01	11.47	0.82	7.88
90°	6.67	13.36	4.13	13.26	1.66	10.53	0.66	7.48

The average for the north facing surfaces is 8.06 and for the south facing surfaces is 17.49 MJ/m² per day. Therefore the percentage of solar radiation from the north (not inducting the gable ends) is $\frac{8.06}{8.06 + 17.49} = 32\%$

This is of course going to vary depending upon the orientation of the particular glazed surfaces of the greenhouse. But it serves as a good illustration and approximation.

This calculation was done for Churchill. Iqaluit has more hours of direct sunlight from the north and thus will have a greater proportion of solar radiation from the north.

APPENDIX C

HEAT LOSS , HEAT GAIN, OIL COSTS

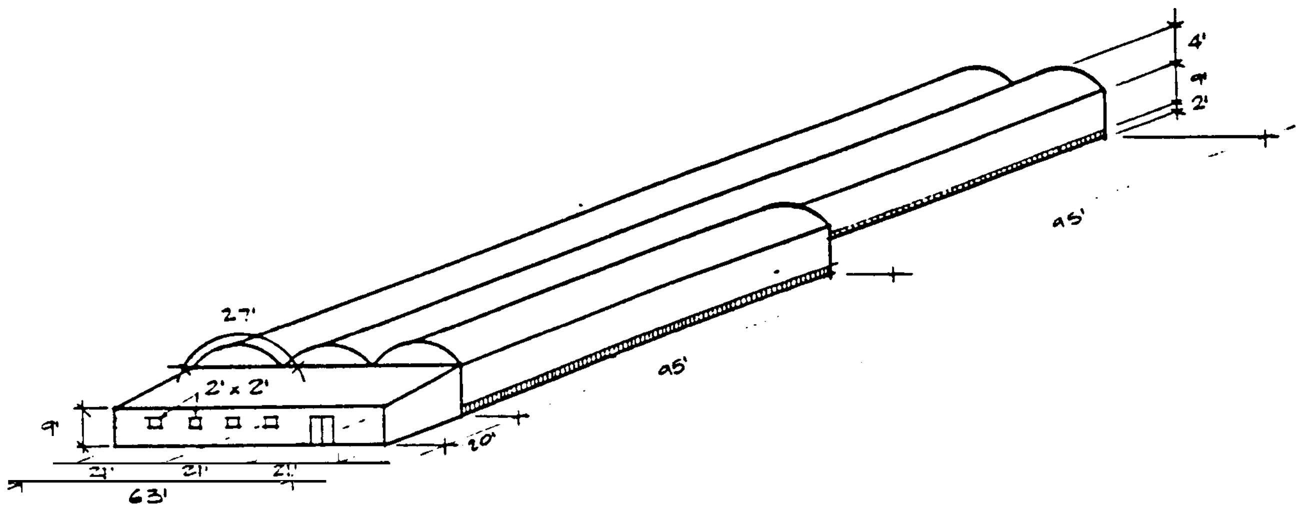


FIGURE 8

The heat loss, solar heat gain, and oil costs for the structure illustrated in Figure 8 were calculated in the following manner. As indicated in Table II of the "Horticultural Design and Production Scenarios", the design temperature of the crops varies considerably. An average indoor temperature of 18oC (64°F) was used. The outdoor design temperature is -40'C (40 OF) .

Design Heat Loss

Knee wall insulated to R27:
[190' + 190' + 63') X 2'] X (64°F - (-400 F))/27 = 3,413 Btu

Glazed gable end with Lexan 1/4'' PCSS, R 1.54:
[9' x 63' + 2/3 x 21' x 4' x3x2] x (640 F- (-40°F))/1.54 = 60,982

Glazed side walls with Lexan 1/4'' PCSS, R 1.54:
[9' x190' + 9' x190'] x(64°F - (-40°F))/1.54 = 230,961

Glazed roof with double polyethylene 6 mil, R 1.42:
[27' X 190' X 2 + 27' X 95'] X (64°F - (-40°F))/1.42 = 939,296

Floor insulated to R25:
[210' x 42' + 115' x 21'] X (64°F - (-25°F))/25 = 17,527

Header house walls inslated to R27:
[20' + 63' + 20'] X 9' X (70°F - (-40°F))/27 = 3,777

Header house roof insulated to R40:
[20' x 63'] X (70°F - (-40°F))/40 = 3,465

Header house windows, R 2.56:
[2' X 2' X 4] X (70°F - (-400 F))/2.56 = 688

Header house doors, R3:
[3' X 7' X 2] X (70°F - (-40°F))/3 = 1,540

Infiltration assuming 1 air change per hour:
[[9' X 21' + 2/3 X 2.1' X 4'] X 475' + 9' X 20' X 63'] X 1.08
x (64°F - (-40°F))/60 = 239,082

Total 1,500,731 Btu

Annual Heating Requirement

Average annual degree days = 17,852°F days/year

$\frac{1,500,7s1}{104}$ $\frac{Btu}{hr. °F}$ X $\frac{24\ hr}{clay}$ X 17,852 $\frac{OF\ days}{year}$ = 6,182,550,000 Btu/year

March to October Heating Requirement

March to October Degree Days = 9,312 $\frac{°F.days}{8\ months}$

$\frac{1,500,3}{104}$ $\frac{Btu}{hr. OF}$ X $\frac{24\ hr}{day}$ X 9,312 $\frac{OF\ days}{year}$ = 3,224,955,000 Btu/year

Solar Heat Gain

This calculation will only be a rough approximation because there are a number of assumptions that have to be rode.

- The calculations are based on values taken from "An Analysis of Solar Radiation Data for Selected Locations in Canada" by J.E. Hay for Churchill, Manitoba. Figures were adjusted for Iqaluit by using the ratio of the average shortwave radiation on a horizontal surface in Iqaluit to that in Churchill.

- Average values are used in the calculations such as:
  - the average daily shortwave radiation on a horizontal surface for the calculation period
  - the average of the daily shortwave radiation values on inclined surfaces from 80° facing south to 80° facing north (for the round roofs of the greenhouse)
  - the average daily shortwave radiation on inclined surfaces for the calculation period.

A computer program would produce more accurate information

- It will be assumed that 45% of the solar heat gain will be lost due to light being reflected from the greenhouse and energy being required for plant transpiration.

Annual Solar Heat Gain

Average annual shortwave radiation on a horizontal surface (Iqaluit)
= 834 Btu/ft² day

Average annual shortwave radiation on a horizontal surface (Churchill)
= 1,007 Btu/ft² day

Glazed west gable end with Lexan 1/4 'PUS, solar transmittance 88%
[9' x 63' +2/3 x21' x 4' x 3] x73? Btu/ft² day x365 day/year x 834/1,007 x .88 x (1 -.4$) = 79,256,000 Btu/year

Glazed upper east gable end with Lexan 1/4"PCSS, solar transmittance 88%
[2/3 x 21' X 4' x 3] x 752 Btu/ft² day x 365 day/year x 834/1,007 x .88 x (1 - .45) = 18,484,000 Btu/year

Glazed south side wall end with Lexan 1/4"PCSS, solar transmittance 88%
[9' r 190'] x 1,127 Btu/ft² day x 365 day/year x 834/1,007 x .88 x (1 - .45) = 281,965,000 Btu/year

Glazed north side wall with Lexan 1/4"PCSS, solar transmittance 88%
[g' x 190'] x 295 Btu/ft² day x 365 day/year x 834/1,007 x .88 x (1 - .45) = 73,806,000 Btu/year

Glazed roof with double polyethylene, solar transmittance 67%
[27' x 190' x 2 + 27' x 95'] x 898 Btu/ft² day x 365 day/year x 834/1,007 x .67 x (1 - .45) = 1,282,323,000 Btu/year

Total 1,736,434,000 Btu/year

Solar Heat Gain from March to October

Average annual shortwave radiation on a horizontal surface (Iqaluit)
= 1186 Btu/ft² day

Average annual shortwave radiation on a horizontal surface (Churchill)
= 1379 Btu/ft² day

Glazed west gable end with Lexan 1/4"PCSS, solar transmittance 88%
[9' x 63' + 2/3 x 21' x 4' x 3] x 959 Btu/ft² day x 245 day/8 mos. x 1,186/1,379 x .88 x (i-.45]: 71,885,000 Btu/8 mos.

APPENDIX D

DISCUSSION OF GREENHOUSE COMPLEX WITH COMMERCIAL NORTHERN GROWERS

Once the greenhouse and horticultural system was developed, other northern greenhouse operators were contacted to determine the feasibility of the plan in the light of their pragmatic experience. 'heir suggestions were solicited on improving the economics of the venture. The following are their key suggestions am-observations. Burdett-Moulton's remarks are in brackets.

Mr. Allan Heiland of Heiland Farms, Whitehorse, Yukon

Mr. Heiland grows produce hydroponically, lettuce and bean sprouts in particular.

- thought that proposed system was logical
- noted that he reduces the temperature in his lettuce greenhouse to 4 °C at night
- in 1978, 90% of the lettuce consumed in Whitehorse was iceberg, the other 10% was romaine and leaf lettuce.
- in 1988, 64% of the lettuce consumed in Whitehorse was iceberg, 18% was romaine, 16% was leaf lettuce, and 2% was butterhead.
- the above was the natural progression of public consumption; he does not know what would happen if larger quantities of fresh, locally grown romaine, leaf, and butterhead lettuce were made available; with his present operation, he may have a better idea in a few months.
- he is presently investigating the use of large growth chambers that can provide more produce per square foot much faster; apparently they are quite new.

John Collette, Fairbanks, Alaska

Mr. Collette grows roses and tomatoes 11) a double polyethylene greenhouse.

notes that tomatoes do not grow well under artificial light because the light cannot penetrate the dense upper foliage to the foliage and tomatoes underneath.

a $750,000 greenhouse was built in McGrath, Alaska to grow tomatoes year round under artificial light; they couldn' t make it work properly.

suggests that, if we. really want to grow tomatoes year round, we get a publication from Rutgers University called "Growing Tomatoes Single cluster" .

he starts his tomatoes the latter part of January, transplants them from March 15 to April 1, and pulls them about the third week of October.

recommends staggered planting to eliminate peak production periods.

has marketable tomatoes from May 20 to November 1.

strongly recommends only growing tomatoes for 8 months of the year and notes that the same problem occurs with cucumbers although not as acute. (We will not consider growing tomatoes or cucumbers for 12 months in the economic analysis) .

feels that lettuce would be a good year round crop.

suggests Alcoa fin tubing for heating because it is very efficient; it is available from Sharp Suppliers on the west coast .

tomatoes are the most difficult crop to grow hydroponically, recommends hiring a horticulturalist who has this capability.

recommends a thermal curtain. (The free heat available from the waste heat recovery pipeline makes this an unnecessary expense. If the pipeline is not installed, a thermal curtain should be installed.)

suggests that the waste heat pipeline be made of a material such as CPVC, use a small diameter pipe (2") with a high temperature difference, and be insulated with fibreglass in order for the system to be as economical as possible. (The estimate for our pipeline is based on fibreglass pipe which is less expensive than CPVC, insulated with sprayed urethane for protection against the severe winds in Iqaluit. The pipeline is 4" with a 60°F temperature drop. If the pipeline was 2", the capital savings would not offset the additional operating costs for the larger circulator that would be required.)

states that a good compromise between insulation and glazing is to have the bottom three feet of the East, South, and West walls well insulated, the bottom six feet of the north wall should be well insulated and the interior surface should be highly reflective. (If the project proceeds, this suggestion will be used.)

Mann Leiser - Alaska Greenhouse, Anchorage, Alaska

Mr. Leiser grows bedding plants and flowers in double glazed fibreglass greenhouses.

- recommends Lexan or double fibreglass greenhouses as opposed to double polyethylene; states that, as the air gap becomes larger than one inch, increasingly large air convective current are set up between the layers of glazing that significantly reduce their thermal resistance. (With the waste heat recovery pipeline, the reduced heat loss from Lexan or fibreglass does not reduce the operating cost. The important consideration is the capital cost.)
- when the decision is made on the glazing, be sure to account for the cost of replacing a layer of polyethylene about every two years. (The capital cost of the polyethylene is about $1,400 every 2 years plus labour.)
- they use Lascalite fibreglass that starts with a light transmission of 91% or 92′% and after twenty years is reduced to 87% to 89%; it has a twenty year warranty,
- they make a double glazed system by installing spacers between two layers of fibreglass.

APPENDIX E

FUNDING SOURCES

As part of the feasibility study for a greenhouse complex in Iqaluit, an initial investigation of potential funding sources was made. If this project proceeds, the following resources should be investigated.

1. Employment & Immigration Canada
   Job Development-Individually Subsidized Jobs

2. Federal Business Development Bank

Regional Offices	Headquarters
5202 Franklin Avenue Yellowknife, N.W.T. X1A 1E2 (403) 873-3556	901 Victoria Square P.O. Box 6021 Montreal, Que. H3C 3C3 (514) 283-5904

3. Business Loans and Guarantees Fund - (403) 873-7363

4. Economic Development Agreement

Local Office	Headquarters
Economic Development & Tourism Economic Development Officer G.N.W.T. Iqaluit, N.W.T X0A 0H0 (819) 979-5311	Manager, Economic Development Secretariat Box 1030 Yellowknife, N.W.T. X1A 2N7 (403) 873-8744

5. Venture Capital Program

Local Office	Headquarters
Economic Development & Tourism Economic Development Officer G.N.W.T. Iqaluit, N.W.T. X0A 0H0 (819) 9'79-5311	2nd Floor Laing Building Economic Development & Tourism, G.N.W.T. Yellowknife, N.W.T. X1A 2L9 (403) 873-7381

6. Northwest Territories Training Strategy

   Employment Enhancement
   Contacts - Employment & Immigration Canada

   Superintendent of Education 979-5236

Training On-The-Job
Contac ts - Superintendent of Education 979-5236

Employment and Apprenticeship Program
Department of Education
Yellowknife, N. W.T.
(403) 873-7552

7. Renewable Resource Business Assistance Program - Schedule D

ECONOMIC ANALYSIS

Iqaluit Greenhouse Feasibility Study

for

The Department of Economic Development and Tourism
Government of the Northwest Territories
Iqaluit, N.W.T.

by

MacKay & Partners, Chartered Accountants

October, 1988

TABLE OF CONTENTS

1. INTRODUCTION

The objective of the analysis presented in this study is to determine which of the eight greenhouse options identified in the "Engineering Design, Capital and Operating Cost Estimates" study is the most feasible. Based on the initial. analysis of the eight options, the best option is further analyzed to determine the level of government assistance necessary to make this option a viable commercial undertaking.

2. OPTIONS EVALUATION

Projected income statements and cash flow statements for eight years have been calculated for each of the eight greenhouse options (see Appendix A). The following assumptions were used in preparing these statements:

1) 100% financing by long term debt
2) Capital financed at 12% per annum, compounded semiannually
3) Revenue and expenses as provided in the 'Engineering Design, Capital and Operating Estimates" study for year 1; for each year after, these estimates were increased 5%
4) Capital costs as provided in the "Engineering resign, Capital and Operating Estimates" study

Table 1 provides a summary of the cash f low totals at the end of eight years for each of the options. As shown in the table, none of the options provides a positive cash flow. Option 7 (10,000 ft^2 greenhouse, with wrote heat recovery, 12 month lettuce growing season, and 8 month tomatoe/cucumber growing season) is the best.

TABLE 1 : PROJECTED CASH FLOW TOTAL FOR THE FIRST 8 YEARS

	Description	Cash Deficit
1.	Option 7 (10,000 ft², waste heat recovery, 12 months lettuce, 8 month tomatoes/cucumbers)	($538,986.00)
2.	Option 3 (7,500 ft², waste heat recovery, 12 months lettuce, 8 months tomatoes/cucumbers)	($661,634.00)
3.	Option 5 (10,000 ft², waste heat recovery, 8 months lettuce, tomatoes and cucumbers)	($668,389.00)
4.	Option 8 (10,000 ft², no waste heat recovery, 12 months lettuce, 8 months tomatoes/cucumbers)	($725,003.00)
5.	Option 6 (10,000 ft², no waste heat recovery, 8 months lettuce, tomatoes and cucumbers)	($733,019.00)
6.	Option 4 (7,500 ft², no waste heat recovery, 12 months lettuce, 8 months tomatoes/cucumbers)	($741,652.00)
7.	Option 2 (7,500 ft², no waste heat recovery, 8 months lettuce, tomatoes and cucumbers)	($746,428.00)
8.	Option 1 (7,500 ft², waste heat recovery, 8 months lettuce, tomatoes and cucumbers)	($752,444.00)

3. FUNDING REQUIREMENTS

In order to make option 7 a viable undertaking for an entrepreneur, a significant grant would be necessary. On the direction of the project management, three financing options were developed that would result in a positive cash flow after eight years of operation.

Detailed projected income statements, cash flow statements, balance sheets for the following three options are provided in Appendix B. Based on the same assumption= as listed above under options evaluation, the following three financing options would result in a positive cash flow.

Option A	*Shareholder Loan	$200,000.00
	Government Grant	$300,000.00
	Long Term Debt	$100,300.00
Option B	*Shareholder Loan	0.00
	Government Grant	$320,000.00
	Long Term Debt	$220,300.00
Option C	*Shareholder Loan	$100,000.00
	Government Grant	$340,000.00
	Long Term Debt	$160,300.00

Table 2 provides a summary of the project cash flow of these three options for an eight year period.

TABLE 2: PROJECTED CASH FLOW FOR EIGHT YEARS

Year	Closing Cash		
	Option A	Option B	option C
1	($2,853.00)	($2,037.00)	($2,445.00)
2	($4,880.00)	($2,048.00)	($3,464.00)
3	($6,042.00)	$ 66.00	($2,988.00)
4	($6,294.00)	$ 228.00	($ 940.00)
5	($5,591.00)	$ 479.00	$2,758.00
6	($2,885.00)	$1,408.00	$6,349.00
7	($1,125.00) "	$3,096.00	$7,426.00
8	$2,987.00	$6,254.00	$9,421.00

* No specific terms for repayment, rate at 12% compounded semiannually.

APPENDIX A

OPTIONS ANALYSIS

IQALUIT GREENHOUSE

GENERAL APPROACH

In compiling these projections, there were 2 general questions. First, which of the eight options was the most feasible, and second, what level of government assistance would be necessary to make the best alternative as determined above economically feasible.

To answer the first question, we prepared cash flow projections for 8 years under each option identified by the project engineers. It was assumed for this that all the required capital would be financed at 12 % per annum, compounded semi-annually. From this we determined that option 7 was the best of the 8, although none were providing a positive cash flow.

The second question was then answered by taking the best option and determining what level of government funding would be required to provide a break even cash flow after eight years. The projected financial statements are prepared based on this determination.

Inherent in the above is that the potential investor requires a 12 % return on his investment (compounded semi-annually) over an eight year period.

MacKay & Partners
Chartered Accountants

P.O. Box 727
MacKay Building
4910 - 50th Street
Yellowknife N.W.T. X1A 2N5
Telephone (403) 920-4404

NOTICE TO READER

We have compiled the accompanying operating projections, source and application of cash flow and balance sheets for the first eight years of operations of Iqaluit Greenhouse from information supplied to us. The principal assumptions and estimates, which were made by project management and upon which the projected financial statements are based, are set forth in the assumptions to the projected financial statements. In order to compile these projected financial statements, we made a review which indicates that the projected financial statements have been compiled on the basis of the assumptions and estimates referred to above. Inasmuch as the projected financial statements and the assumptions and estimates relate to the future and may be affected by unforeseen events, we can express no opinion on the projected financial statements or on how closely they will correspond with the actual results, or on the assumptions on which they are based. No representation may be made or implied that we take any responsibility for the accuracy of the projected financial statements.

MacKay & Partners
CHARTERED ACCOUNTANTS

Yellowknife, Northwest Territories
September 30, 1988

[illegible] GREENHOUSE

VARIABLES
(Unaudited - See Notice To Reader)

OPTION: 1
7,500 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 8 MONTH SEASON

INFLATION 5%

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
LTD PRINCIPAL	43,178	47,866	53,782	60,429	67,898	76,290	85,720	94,837
LTD INTEREST	59,182	54,494	48,578	41,931	34,462	26,070	16,640	6,045
	102,360	102,360	102,360	102,360	102,360	102,360	102,360	100,882

CAPITAL COST:

BUILDING	389,500
HEAT EXCHANGE	119,000
OTHER EQUIPME	21,500
	530,000

GOVERNMENT GR	0
LONG TERM DEB	530,000
	530,000

REVENUE & EXPENSES - YEAR 1

Lettuce	41,280
Tomato	25,680
Cucumber	[illegible]
	78,135

Wages and ben	45,000
Growing suppl	2,470
Electricity	11,410
Water	1,200
Oil	0
Repairs and m	2,000
Miscellaneous	800
Property taxe	3,500
Professional	1,000
Insurance	2,600
Office	600
Telephone	750
	71,330

IQALUIT GREENHOUSE

PROJECTED INCOME
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 1
7,500 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 8 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
REVENUE								
Lettuce	$41,290	$43,344	$45,511	$47,797	$50,176	$52,685	$55,319	$58,085
Tomato	25,680	26,964	28,312	29,728	31,214	32,775	34,414	36,135
Cucumber	11,175	11,734	12,321	12,937	13,584	14,263	14,976	15,725
	[illegible]	82,042	86,	90,452	94,974	99,723	104,709	109,945
Cost of sales								
Wages and benefits	45,000	47,250	49,613	52,094	54,699	57,434	60,306	63,321
Growing supplies	2,470	2,594	2,724	2,860	3,003	3,153	3,311	3,477
	47,470	49,844	52,337	54,954	57,702	60,587	63,617	66,798
Gross margin	30,665	32,198	33,807	35,498	37,272	39,136	41,092	43,147
EXPENSES								
Electricity	11,410	11,981	12,580	13,209	13,869	14,562	15,290	16,055
Water	1,200	1,260	1,323	1,389	1,459	1,531	1,608	1,688
Oil	0	0	0	0	0	0	0	[illegible]
Repairs and maintenance	2,000	2,100	2,205	2,315	2,431	2,553	2,681	2,815
Miscellaneous	800	840	882	926	972	1,021	1,072	1,126
Property taxes	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,925
Professional fees	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Insurance	2,600	2,730	2,867	3,010	3,161	3,319	3,485	3,659
Office	600	630	662	695	730	767	805	845
Telephone	750	788	827	868	911	957	1,005	1,055
Interest on LTD	59,182	54,494	48,578	41,931	34,462	26,070	16,540	6,045
Amortization of grant	0	0	0	0	0	0	0	0
Depreciation	29,725	27,594	25,698	24,000	22,470	21,082	19,817	18,557
	112,767	107,142	100,584	93,553	85,935	77,507	613,425	58,279
INCOME BEFORE TAXES	(82,102)	(74,944)	(66,777)	(58,055)	(48,663)	(38,471)	(27,343)	(15,132)
INCOME TAXES @ 25%	0	0	0	0	0	0	0	0
NET INCOME	($82,102)	($74,944)	($66,777)	($58,055)	($48,663)	($38,471)	($27,343)	($15,132)

IQALUIT GREENHOUSE

PROJECTED CASH FLOW
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 1
7,500 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 8 MONTH SEASON

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Net Income	($82,102)	($74,344)	($66,777)	($58,055)	($48,663)	($38,471)	($27,343)	($15,132)
Amortization	0	0	0	0	0	0	0	0
Depreciation	29,725	27,594	25,598	24,000	22,470	21,082	19,817	18,657
LTD principle	(43,179)	(47,866)	(53,782)	(60,429)	(67,998)	(76,290)	(85,720)	(94,837)
From Operations	($95,555)	($95,216)	($94,861)	($94,484)	($94,091)	($93,679)	($93,246)	($91,312)
Opening cash	0	(95,555)	(190,771)	(285,632)	(380,116)	(474,207)	(567,886)	(661,132)
Closing cash	($95,555)	($190,771)	($285,632)	($380,116)	($474,207)	($567,886)	($661,132)	($752,444)

[illegible] GREENHOUSE

VARIABLES
(Unaudited - See Notice To Reader)

OPTION: 2
7,500 SQ. FT. - WITHOUT HEAT EXCHANGE EQUIPMENT 8 MONTH SEASON

INFLATION 5%

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
LTD PRINCIPAL	33,486	37,122	51,710	46,865	52,658	59,166	66,479	73,514
LTD INTEREST	45,894	42,258	27,670	32,515	26,722	20,214	12,901	4,684
	79,380	79,380	79,380	79,380	79,380	79,380	79,380	73,198

CAPITAL COST:

BUILDING	389,500
HEAT EXCHANGE	0
OTHER EQUIPME	21,500
	411,000

GOVERNMENT GR	0
LONG TERM DEB	411,000
	411,000

REVENUE & EXPENSES - YEAR

Lettuce	41,280
Tomato	25,680
Cucumber	11,175
	78,135

Wages and ben	45,000
Growing suppl	2,470
Electricity	7,800
Water	1,200
Oil	22,200
Repairs and m	2,000
Miscellaneous	800
Property taxe	3,500
Professional	1,000
Insurance	2,500
Office	500
Telephone	750
	89,720

IQALUIT GREENHOUSE

PROJECTED INCOME
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 2
7,500 SQ. FT. - WITHOUT HEAT EXCHANGE EQUIPMENT 8 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
REVENUE								
Lettuce	$41,280	$43,344	$45,511	$47,787	$50,176	$52,685	$55,319	$58,085
Tomato	25,680	26,964	28,312	29,728	31,214	32,775	34,414	36,135
Cucumber	11,175	11,734	12,321	12,937	13,584	14,263	14,376	15,725
	78,135	82,042	86,144	90,452	94,974	99,723	104,709	109,945
Cost of sales								
Wages and benefits	45,000	47,250	49,613	52,094	54,699	57,434	60,306	63,321
Growing supplies	2,470	2,594	2,724	2,860	3,003	3,153	3,311	[illegible]
	47,470	49,844	52,337	54,954	57,702	60,587	63,617	66,798
Gross margin	30,665	32,198	33,807	35,498	37,272	39,136	41,092	43,147
EXPENSES								
Electricity	7,800	8,190	8,600	9,030	9,482	9,956	10,454	10,977
Water	1,200	1,260	1,323	1,389	1,459	1,531	1,608	1,688
Oil	22,200	23,310	24,476	25,700	26,985	28,334	29,751	31,239
Repairs and maintenance	2,000	2,100	2,205	2,315	2,431	2,553	2,681	2,815
Miscellaneous	900	940	982	926	972	1,021	1,072	1,126
Property taxes	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,926
Professional fees	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Insurance	2,600	2,730	2,867	3,010	3,161	3,319	3,485	3,659
Office	500	530	562	695	730	767	805	845
Telephone	750	788	827	868	911	957	1,005	1,055
Interest on LTD	45,994	42,258	37,679	32,515	26,722	20,214	12,901	4,684
Amortization of grant	0	0	0	0	0	0	0	0
Depreciation	23,775	21,941	20,329	18,899	17,624	16,478	15,443	14,502
	112,119	108,772	104,802	100,557	95,947	90,875	85,237	78,924
INCOME BEFORE TAXES	(81,454)	(76,574)	(70,995)	(65,059)	(58,675)	(51,739)	(44,145)	(35,777)
INCOME TAXES @ 25%	0	0	0	0	0	0	0	0
NET INCOME	($81,454)	($76,574)	($70,995)	($65,059)	($58,675)	($51,739)	($44,145)	($35,777)

IQALUIT GREENHOUSE

PROJECTED CASH FLOW
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 2
7,500 SQ. FT. - WITHOUT HEAT EXCHANGE EQUIPMENT 8 MONTH SEASON

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 5	Year 7	Year 8
Net Income	($81,454)	($78,574)	($70,995)	($65,059)	($58,575)	($51,739)	($44,[illegible])	($35,777)
Amortization	0	0	0	0	0	0	0	0
Depreciation	23,773	21,941	20,328	18,899	17,624	16,478	15,443	14,502
LTD principle	(33,496)	(37,122)	(41,710)	(46,965)	(52,658)	(59,166)	(66,479)	(73,514)
From Operations	($91,165)	($91,755)	($92,377)	($93,025)	($93,703)	($94,427)	($95,181)	($94,789)
Opening cash	0	(91,165)	(182,920)	(275,297)	(368,322)	(462,031)	(556,458)	(651,639)
Closing cash	($91,165)	($182,920)	($275,297)	($368,322)	($462,031)	($556,458)	($651,639)	($746,429)

IQALUIT GREENHOUSE

VARIABLES
(Unaudited - See Notice To Reader)

OPTION: 3
7,500 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

INFLATION 5%

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
LTD PRINCIPAL	43,168	47,866	53,782	60,429	67,898	76,290	85,720	94,837
LTD INTEREST	59,192	54,494	48,578	41,931	34,462	26,070	16,640	6,045
	102,360	102,360	102,360	102,360	102,360	102,360	102,360	100,882

CAPITAL COST:

BUILDING	389,500
HEAT EXCHANGE	119,000
OTHER EQUIPME	21,500
	530,000

GOVERNMENT GR	0
LONG TERM DEB	530,000
	530,000

REVENUE & EXPENSES - YEAR

Lettuce	67,080
Tomato	25,680
Cucumber	11,175
	103,935

Wages and ben	45,000
Growing suppl	2,645
Electricity	26,500
Water	1,375
Oil	0
Repairs and m	2,400
Miscellaneous	1,000
Property taxe	3,500
Professional	1,000
Insurance	2,600
Office	700
Telephone	900
	87,620

IQALUIT GREENHOUSE

PROJECTED INCOME
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 3
7,500 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
REVENUE								
Lettuce	$67,080	$70,434	$73,956	$77,654	$81,537	$85,614	$89,895	$94,390
Tomato	25,680	26,964	28,312	29,728	31,214	32,775	34,414	36,135
Cucumber	11,175	11,734	12,321	12,937	13,584	14,263	14,976	15,725
	103,935	109,132	114,589	120,319	126,335	132,652	139,185	146,250
Cost of sales								
Wages and benefits	45,000	47,250	49,613	52,094	54,699	57,434	60,306	63,321
Growing supplies	2,645	2,777	2,916	3,062	3,215	3,376	3, 545	3,722
	47, 645	50,027	52,529	55,156	57,914	60,810	63,851	67,043
Gross margin	56,290	59,105	62,060	65, 163	68,421	71,842	75, 334	79,207
EXPENSES								
Electricity	26,500	27,825	29,216	30,677	32,211	33,822	35,513	37,289
Water	1,375	1,444	1,516	1,592	1,672	1,756	1,844	1,936
Oil	0	0	0	0	[illegible]	0	0	0
Repairs and maintenance	2,400	2,520	2,646	2,778	2,917	3,063	3,216	3,377
Miscellaneous	1,000	1,050	1,103	1,158	1,[illegible]	1,277	1,341	1,408
Property taxes	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,926
Professional fees	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Insurance	2,600	2,730	2,867	3,010	3,161	3,319	3,485	3,659
Office	700	735	772	811	852	895	940	987
Telephone	900	945	992	,042	1,094	1,149	1,206	1,266
Interest on LTD	59,182	54,494	48,578	4 ,931	34,462	26,070	16,640	6,045
Amortization of grant	0	0	0	0	0	0	0	0
Depreciation	29,725	27,594	25,698	24,000	22,470	21,082	19,817	18,657
	128,882	124,062	118,350	112,209	105,526	98,178	90,034	80,958
INCOME BEFORE TAXES	(72,592)	(64,957)	(56,290)	(47,046)	(37, 105)	(26,336)	14,600)	(1,751)
INCOME TAXES @ 25%	0	0	0	0	0	0	0	0
NET INCOME	($72,592)	($64, 957)	($56,290)	($47, 046)	($37, 105)	($26,336)	($14,600)	($1,751)

IQALUIT GREENHOUSE

PROJECTED CASH FLOW
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 3
7,500 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Net Income	($72,592)	($64,957)	($56,290)	($47,046)	($37,105)	($26,336)	($14,500)	($1,751)
Amortization	0	0	0	0	0	0	0	0
Depreciation	29,725	27,594	25,638	24,000	22,470	21,082	19,817	18,657
LTD principle	(43,178)	(47,866)	(53,782)	(60,429)	(67,898)	(76,290)	(85,720)	(94,337)
From Operations	($86,045)	($85,229)	($84,374)	($83,475)	($82,533)	($81,544)	($80,503)	($77,331)
Opening cash	0	(86, 045)	(171,274)	[illegible]	[illegible]	(421 ,65)	(503,200)	(583,703)
Closing cash	($86,045)	($171, 274)	($255,648)	($339, 123)	($421, 656)	($503,200)	($583,703)	($661 ,634)

IQALUIT GREENHOUSE

VARIABLES
(Unaudited - See Notice To Reader)

OPTION: 1
7,500 SQ. FT. - WITHOUT HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

INFLATION 5%

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
LTD PRINCIPAL	33,486	37,122	41,710	46,865	52,658	59,166	66,479	73,514
LTD INTEREST	45,894	42,258	37,670	32,515	26,722	20,214	12,901	4,684
	79,380	79,380	79,380	79,380	79,380	79,380	79,380	78,198

CAPITAL COST:

BUILDING	389,500
HEAT EXCHANGE	0
OTHER EQUIPME	21,500
	411,000

GOVERNMENT GR	0
LONG TERM DEB	411,000
	411,000

REVENUE & EXPENSES - YEAR 1

Lettuce	67,080
Tomato	25,680
Cucumber	11,175
	103,935

Wages and ben	45,000
Growing suppl	2,645
Electricity	20,600
Water	1,375
Oil	33,500
Repairs and m	2,400
Miscellaneous	1,000
Property taxe	3,500
Professional	1,000
Insurance	2,600
Office	700
Telephone	900
	115,220

IQALUIT GREENHOUSE

PROJECTED INCOME
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 4
7,500 SQ. FT. - WITHOUT HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
REVENUE								
Lettuce	$67,080	$70,434	$73,956	$77,654	$81,537	$85,614	$83,975	$94,390
Tomato	25,580	26,864	28,212	29,728	31,214	32,775	34,414	36,135
Cucumber	11,175	11,734	12,321	12,937	13,584	14,263	14,976	15,725
	103,835	109,029	114,589	120,319	126,335	132,652	139,285	146,250
Cost of sales								
Wages and benefits	45,000	47,250	49,613	52,094	54,699	57,434	60,306	63,321
Growing supplies	2,645	[illegible]	2,916	3,062	3,215	3,376	3,545	3,722
	47,645	50,027	52,529	55,156	57,914	60,810	63,851	67,043
Gross margin	56,290	59,105	62,060	65,163	68,421	71,842	75,424	79,207
EXPENSES								
Electricity	20,500	21,530	22,712	23,848	25,040	26,292	27,607	28,987
Water	1,375	1,444	1,516	1,592	1,672	1,756	1,844	1,936
Oil	33,500	35,175	36,934	38,781	40,720	42,756	44,894	47,139
Repairs and maintenance	2,400	2,520	2,646	2,778	2,917	3,063	3,216	3,377
Miscellaneous	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Property taxes	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,926
Professional fees	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Insurance	2,600	2,730	2,867	3,010	3,161	3,319	3,485	3,659
Office	700	735	772	811	852	895	940	987
Telephone	900	945	992	1,042	1,094	1,149	1,206	1,266
Interest on LTD	45,894	42,258	37,570	32,515	26,722	20,214	12,901	4,684
Amortization of grant	0	0	0	0	0	0	0	0
Depreciation	23,775	21,941	20,329	18,899	17,624	16,478	15,443	14,502
	137,244	135,153	132,502	129,644	125,489	122,944	118,909	114,279
INCOME BEFORE TAXES	(80,954)	(76,048)	(70,442)	(64,481)	(59,068)	(51,102)	(43,475)	(35,072)
INCOME TAXES @ 25%	0	0	0	0	0	0	0	0
NET INCOME	($80,954)	($76,048)	($70,442)	($64,481)	($58,983)	($51,102)	($43,475)	($35,072)

IQALUIT GREENHOUSE

PROJECTED CASH FLOW
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 4
7,500 SQ. FT. - WITHOUT HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Net Income	($80,954)	($76,048)	($70,442)	($64,481)	($58,068)	($51,102)	($43,475)	($35,072)
Amortization	0	0	0	0	0	0	0	0
Depreciation	23,775	21,941	20,328	18,899	17,624	16,478	15,443	14,502
LTD principle	(33,486)	(37,122)	(41,710)	(46,865)	(52,658)	(59,166)	(66,479)	(73,514)
From Operations	($90,665)	($91,229)	($91,824)	($92,447)	($93,102)	($93,790)	($94,511)	($94,084)
Opening cash	0	(90,665)	(181,894)	(273,718)	(366,165)	$459,267	(553,057)	(647,568)
Closing cash	($90,665)	($181,894)	($273,718)	($366,165)	($459,267)	($553,057)	($647,568)	($741,652)

APPENDIX B

FUNDING & FINANCING ANALYSIS

IQALUIT GREENHOUSE

OPERATING PROJECTIONS
(unaudited - See Notice to Reader)

FOR THE FIRST EIGHT YEARS

MacKay & Partners
Chartered Accountants

P O Box 727
MacKay Building
4910. 50th Street
Yellowknife, N W T X1A 2N5
Telephone (403) 920-4404

NOTICE TO READER

We have compiled the accompanying operating projections, source and application of cash flow and balance sheets for the first eight years of operations of Iqaluit Greenhouse from information supplied to us. The principal assumptions and estimates, which were made by project management and upon which the projected financial statements are based, are set forth in the assumptions to the projected financial statements. In order to compile these projected financial statements, we made a review which indicates that the projected financial statements have been compiled on the basis of the assumptions and estimates referred to above. Inasmuch as the projected financial statements and the assumptions and estimates relate to the future and may be affected by unforeseen events, we can express no opinion on the projected financial statements or on how closely they will correspond with the actual results, or on the assumptions on which they are based. No representation may be made or implied that we take any responsibility for the accuracy of the projected financial statements.

MacKay & Partners
CHARTERED ACCOUNTANTS

Yellowknife, Northwest Territories
September 30, 1%38

IQALUIT GREENHOUSE

OPERATING PROJECTIONS
(Unaudited - See Notice to Reader)

FOR THE FIRST EIGHT YEARS

OPTION A

IQALUIT GREENHOUSE

PROJECTED INCOME
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 7
[0,000 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
REVENUE								
Lettuce	$89,440	$93,912	$98,608	$103,538	%108,715	$114,151	$119,859	$125,852
Tomato	34,240	35,952	37,750	39,638	41,620	43,701	45,886	48,180
Cucumber	14,900	15,645	16,427	17,248	18,110	19,016	19,967	20,965
	138,580	145,509	152,785	160,424	168,445	176,868	185,712	194,997
Cost of sales								
Wages and benefits	69,000	72,450	76,073	79,877	83,871	88,065	92,468	97,091
Growing supplies	3,540	3,717	3,903	4,098	4,303	4,518	4,744	4,981
	72,540	76,167	79,976	83,975	08,174	92,583	97,212	102,072
Gross margin	66,040	69,342	72,809	76,449	80,271	84,285	88,500	92,925
EXPENSES								
Electricity	33,400	35,070	36,824	38,665	40,598	42,628	44,759	46,997
Water	1,825	1,916	2,012	2,113	2,219	2,330	2,447	2,569
Oil	0	0	0	0	0	0	0	0
Repairs and maintenance	2,900	3,045	3,197	3,357	3,525	3,701	3,886	4,080
Miscellaneous	1,200	1,260	1,323	1,389	1,458	1,531	1,608	1,688
Property taxes	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,926
Professional fees	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Insurance	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,926
Office	1,000	"1,050	1,103	1,158	1,216	1,277	1,341	1,408
Telephone	1,200	1,260	1,323	1,389	1,458	1,531	1,608	1,688
interest on LTD	11,200	10,313	9,194	7,937	6,524	4,936	3,153	1,148
Amortization of grant	(16,687)	(15,515)	(14,470)	(13,529)	(12,681)	(11,909)	(11,203)	(10,555)
Depreciation	33,390	31,046	28,953	27,073	25,374	23,830	22,417	21,119
	77,428	77,845	78,280	78,814	79,417	80,068	80,739	81,402
INCOME BEFORE TAXES	(11,388)	(8,503)	(5,471)	(2,365)	854	4,217	7,761	11,523
INCOME TAXES @ 25%	0	0	0	0	0	0	0	0
NET INCOME	($11,388)	($8,503)	($5,471)	($2,365)	$854	$4,217	$7,761	$11,523
NET INCOME	($11,388)	($8,503)	(45,471)	($2,36S)	S8S4	$4,217	$7,761	S11,523
Depreciation	33,390	31,046	28,953	27,073	25,374	23,830	22,417	21,119
Amortization	(16,6871	(15,515)	(14,470)	(13,529)	(12,681)	(11,909)	(11,203)	(10,555)
C.C.A.	(36,6291	(28,097)	(19,691)	(15,116)	(12,490)	(10,873)	(9,787)	(8,989)
TAXABLE INCOME	($31,314)	($21,069)	($10,679)	($3,937)	$1,0s7	%5,265	$9,180	$13,090

IQALUIT GREENHOUSE

PROJECTED CASH FLOW
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

TION: 7
.0,000 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Net Income	($11,388)	($8,503)	($5,471)	($2,365)	$854	$4,217	$7,761	$11,523
Amortization	(16,687)	(15,515)	(14,470)	(13,529)	(12,681)	(11,909)	(11,203)	(10,555)
Depreciation	33,390	31,046	28,953	27,073	25,374	23,830	22,417	21,119
LTD principle	(8,168)	(9,055)	(10,174)	(11,431)	(12,844)	(14,432)	(16,215)	(17,981)
From Operations	(2,853)	(2,027)	(1,1621	(252)	703	1,706	2,760	4,106
Opening cash	0	(2,853)	(4,880)	(6,042)	(6,294)	(s,591)	(3,885)	(1,125)
Closing cash	($2,853)	($4,880)	($6,042)	($6,294)	($5,591)	($3,8851	($1,125)	$2,981

IQALUIT GREENHOUSE

PROJECTED BALANCE SHEET

ASAT YEAR END
(Unaudited -See Notice To Reader)

OPTION: 7
10,000SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEARS	YEAR 6	YEAR 7	YEAR 8
ASSETS								
CURRENT								
Cash	($2,853)	($4,880)	($6,042)	($6,294)	($5,591)	($3,885)	($1,125)	$2,981
FIXED								
cost	600,300	600,300	600,300	600,200	600,300	600,300	600,300	600,300
Accumulated depreciation	(33,390)	(64,436)	(93,389)	(120,462)	(145,836)	(169,666)	(192,083)	(213,202)
	S66,910	535,864	506,911	479,830	454,464	430,634	408,217	387,098
	$S64,037	S530,984	$S00,869	$473,544	$448,873	$426,749	$407,092	$390,079

LIABILITIES & EQUITY								
SHAREHOLDERS LOAN	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000
GOVERNMENT ASSISTANCE	283,313	267,798	253,328	239,799	227,118	215,209	204,006	193,451
LONG TERM DEBT	92,132	83,077	72,903	61,472	48,628	34,196	17,981	0
RETAINED EARNINGS	(11,388)	(19,891)	(25,362)	(27,727)	(26,873)	(22,6S6)	(14,89S)	(3,372)
	$564,057	$530,984	$S00,069	$473,544	$448,873	S426,749	S407,092	$390,079

IQALUIT GREENHOUSE

PROJECTED DEPRECIATION
FOR THE FIRST 8 YEARS
(Unaudited -See Notice To Reader)

OPTION: 7
10,000SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	Cost	Rate	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
ACCOUNTING										
Equipment	$22,500	20%	$4,500	$3,600	$2,880	$2,304	$1,843	$1,475	$1,180	$944
Buildings	458,800	5%	22,940	21,793	20,703	19,668	18,685	17,751	16,863	16,020
	481,300		27,440	25,393	23,583	21,972	20,520	19,226	18,043	16,964
Heat exchange	119,000	5%	5,950	5,653	5,370	5,101	4,846	4,604	4,374	4,155
	$600,300		$33,390	$31,046	$20,953	$27,073	$25,374	$23,030	$22,417	$21,119
TAX (C.C.A.)										
Equipment	$11,256	20%	$1,126	$2,026	$1,621	$1,297	$1,037	$830	$664	$531
Buildings	229,515	5%	5,738	11,189	10,629	10,098	9,593	9,113	8,658	8,225
	240,771		6,864	13,215	12,250	11,395	10,630	9,943	9,322	8,756
Heat exchange	59,529	50%	29,765	14,882	7,441	3,721	1,860	930	465	233
	$300,300		$36,629	$28,097	$19,691	$15,116	$12,490	$10,873	$9,787	$8,989
GOVERNMENT ASSISTANCE										
Equipment	$11,244	20%	$2,249	$1,799	$1,439	$1,151	S921	$137	$590	$472
Buildings	229,285	5%	11,464	10,891	10,347	9,829	9,338	8,871	8,427	8,006
	240,529		13,713	12,690	11,786	10,980	10,259	9,608	9,017	8,478
Heat exchange	59,471	5%	2,974	2,825	2,684	2,549	2,422	2,301	2,186	2,0n
	$300,000		$16,687	$15,515	$14,470	$13,529	$12,681	$11,909	$11,203	$10,555

Option A

LOAN AMORTIZATION SCHEDULE

Oct 11, 198a

Borrower :IQALUIT GREENHOUSE Description :LOAN

ender :

rincipal: 100300.00 Paymen t : 1614.00 payable every 1 month (s)

Inter est rate : 1:. 0000 Compounded every 6 month(s)

tar t : 1'3a5\03Jo 1 1st : 1'3a'3/os/28 Last : 1'3'37/0'2/'28 Maturity :1997/02/28

Date	Interest	Principal	Balance
1. Mar 28 1'38'3	868.38	745.62	'39554.?/8
2. Apr 28 1 989	'371.53	642.47	98'311 . 92
3. May 28 1989	965.26	64a. 74	38262.18
4. Jun 28 1989	958 .92	655.07	97(508. 11
5 . Jul 28 1989	952 .54	661.46	96946.64
6. Aug 2a 1989	946 .08	667.92	96278.72
7. Sep 28 1989	939.56	674.44	95 604.29
8 . Oct 28 1989	932.98	681.02	94923·27
9 . Nov 28 1989	926.34	687.66	94235.51
10. Dec 28 1989	91'3. 63	694.37	93541.24
11. Jan 2a 1990	1312.95	701.15	92840.0'3
12. Feb 28 1990	9(:)15 . ()1	707.99	92132.09
Sub Total	112(](>.09	81157.91	
13. Mar 28 1"3'3(:)	8'3'3. 10	714. 90	'314 17. 19
14. Apr 28 1990	8$32.12	721.88	'306'35 .31
15. May 28 1'3'3(>	885.08	72a. 92	89966.39
16. Jun 28 1990	877.96	736.04	89230.35
17. Jul 28 1'3'3(3	870.78	743.22	88487 .13
18. Aug 28 1'3'30	863.53	750.47	87736.66
19. Sep 28 1990	856.20	737. 80	86978 .86
20. Oct 28 19'3(:)	848. 81	765.19	a6212 .67
21. Nov 28 1990	841.24	772..66	85441.02
22. Dec 28 1'3"3(:)	833.80	78(:).20	846150.82
23. Jan 28 1'3"31	826.19	7a7. 81	83873 .00
24. Feb 28 1991	a 18. 50	755. 50	83077.50
Sub Total	1 (3312. 41	9054.59	
25. Mar 28 1'3'31	a10.74	803.26	82274·24
26. Apr 28 1991	802. 90	811.10	81463.14
27. May 28 1'3'31	7'34. 98	819.02	80644.12
28. Jun 28 1 '391	786.99	827.01	79817.11
29. Jul 28 1991	77a. 92	835.08	78'382 .03
30. Aug 28 1991	770.77	843.23	78138. 80
31. Sep 28 1 '391	762.54	851.46	77287.34
32. Oct 28 1991	754. 23	859.77	76427.57
33 ' Nov 28 1991	745.84	8.58.16	75553.41
34. Dec 28 1991	727.37	876.63	74682.78

Option A

LOAN AMORTIZATION SCHEDULE

Oct 11, 1989

Bor r ower : IQALUIT GREENHOUSE Description :LOAN
.ender : :
'r i n c i pal : 100300.00 Payment : 1614.00 payable every 1 month(s)
Interest rate : 12.0000 Compounded every 6 mont h (s)
Start:1989/03/01 1st :154854 /03/28 Last : 1'3'37/(:)~/~8 Mat ur i t y :1997/02/28

Date	Inter est	Pr i nc i pal	Bal anc e
35. Jan 28 1992	728.81	885. 19	73797.59
36. Feb 28 1992	720.18	893.82	72903 .77
Sub Tot al	'3194.26	10173.74	
27. Mar 28 1992	711.45	902 .55	72001.22
38. Apr 28 1992	702.65	911.25	71 089 .86
29. May 28 1992	693 .75	920.25	7(j115'3 ● 62
40• Jun 28 1992	684.77	923.22	6'3240. 39
41. Jul 28 1992	675. 70	938.30	68302. 09
42. Aug 28 1992	666.55	947.45	67254.64
43. Sep 28 1992	657·30	'356 . 70	66397.'34
44. Oc t 28 1992	647.96	'366. 04	6!5431 . '30
45. Nov 28 1992	638.54	'375 . 46	64456.44
46 . Dec 28 1992	629.02	984. '38	63471.45
47. Jan 28 1993	E11'3 .40	'3'34 .60	62476.86
40. Feb 28 1993	609.70	1004 .30	61472. 56
Sub Total	7936.79	11431.21	
49. Mar 28 1993	599·90	1014.10	15(3458 ● 45
50. Apr 28 1993	590,00	1024.00	55434. 46
51. May 28 1993	580.01	1033 .99	58400.47
52· Jun 28 1993	569.92	1044.08	57256.28
53 . Jul 28 1993	559 .73	1054.27	56202.11
54. Aug 28 1993	549 .44	1064.56	55237 .55
55. Sep 28 1993	539.05	1074. '35	54162.61
56. Oc t 28 1993	528.55	1085.44	53077·17
57 . Nov 28 1993	51 7.97	109.5.02	51981.14
58. Dec "28 1993	507·"27	1106.73	50874 .41
59. Jan 28 1994	496 .47	1117.53	4'3756 .88
60. Feb 28 1994	485.57 "	1128.43	48628.45
Sub Total	6523.8'3	12844.11	
61. Mar 28 1'394	474.56	1139.44	47489. 00
62. Apr 28 1994	463.44	1150.56	46338. 44
63. May 28 1994	452 .21	1161. 79	45176.65
64 . Jun 28 1994	440 .87	11 73. 13	44003.52
65 . Jul 28 1994	425.42	1184.58	42818. 94

Option A

LOAN AMORTIZATION SCHEDULE Oct 11, 1988

:rrower : IL! ALUIT IX? REENHOUSE Description :LOAN
ender : :
-incipa1 : 1[:1(:)2(:)(:). 00 **Payment:** 1614.00 **payable every** 1 month(s)
nterest rate : 12.0000 Compounded every 6 month(s)
:art : 1'2f3'3/03/01 1 St : 1989/03/28 Last : 1997/02/28 Maturity : 1'3'37/02/28

Date	Interest	Principal	Balance
56. Aug 28 1994	417.86	11;36 .14	4 1622 80
57. Sep 28 1994	406. 19	1207.81	40414. "3"3
58. Oct 28 1'3'34	334.40	121"3.60	3"3 195. 39
59. Nov 28 1994	382 . 50	1231.50	37963. 89
70. Dec 28 1'3'34	370.48	1243.52	36720.37
71. Jan 28 1995	358. 35	1255.65	25464. 72
72. Feb 28 1995	346. 09	1 267."31	341 '36 .81
Sub Total	4936.36	14431.64	
73. Mar 28 1995	333.72	1280.28	32'31 6.53
74. Apr 28 1995	321•23	12'32 ● 77	31623 . 75
75. May 28 1 995	308 .61	1305 .35	3(3318.36
76. Jun 28 1995	2'35 .87	1216.13	29000.24
77. Jul 28 1995	283.01	1 32(], 9'3	27669 .24
78. Aug 28 1995	270. 02	1343.98	26325.26
79. Sep 28 1 995	256.90	1357.10	24968.16
80. Oct 28 1995	242.66	1370,34	23597 .82
81. Nov 28 1995	230.29	1383.71	22214. 11
82. Dec 28 1995	216 .78	13'37. 22	20816. 89
83. Jan 28 1996	203.15	1410.85	1'3406 .04
84. Feb 28 19136	189.38	1424. 62	17981.42
Sub Total	3152.61	16215. 39	
85. Mar 28 1'3'36	175.48	1438 .52	16542. 90
86. Apr 28 1 '396	161.44	145~. 56	150'30 .24
87. May 28 1'39EI	147.26	1466.74	13623.60
88. Jun 28 1'3'36	132.95	1481.05	12142.55
89 . Jul 28 1'3'36	118. 50	14'35.50	10647.05
90. Aug 28 1'3'36	103.90	1510.10	9136.'35
91. Sep 28 1'3'36	89. 17	15224.83	7612.11
92. Oct 28 1'3'36	74. 29	153"3 .71	6072.40
921. Nov 28 1'3"36	59.26	1554.74	4517.66
94. Dec 28 1'3'36	44. 09	1569.'31	2'347. 74
95. Jan 28 1997	28.77	1585.23	1362.51
'36. Feb 28 1'3'37	12.30	1600.70	-238.19
Sub Total	1148.39	18219.61	

IQALUIT GREENHOUSE

PROJECTED INCOME
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 5
10,000 SQ. FT. - WITHOUT HEAT EXCHANGE EQUIPMENT 8 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
REVENUE								
Lettuce	$55,040	$57,792	$60,682	$63,716	$66,902	$70,247	$73,759	$77,447
Tomato	34,240	35,952	37,750	39,638	41, EN	43,701	45,886	48,180
Cucumber	14,900	15,645	16,427	17,248	18,1 10	19,016	19,967	20,965
	104,180	109,389	114,859	120,602	126,632	132,964	139,612	146,592
Cost of sales								
Wages and benefits	45,000	47,250	49,613	52,094	54,699	57,434	60,306	63,321
Growing supplies	3,305	3,470	3,644	3,826	4,017	4,218	4,429	4,650
	48,305	50,720	53,257	55,920	58,7!6	61,652	64,735	67,971
Gross margin	55,875	58,669	61,602	64,682	67,916	71,312	74,877	78,621
EXPENSES								
Electricity	10,400	10,920	11,466	12,039	12,641	13,273	13,937	14,634
Water	1,600	1,680	1,764	1,852	1,945	2,042	2,144	2,251
Oil	29,600	31,080	32,634	34,266	35,979	37,778	39,667	41,650
Repairs and maintenance	2,500	2,625	2,756	2,894	3,039	3,191	3,351	3,519
Miscellaneous	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Property taxes	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,926
Professional fees	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Insurance	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,926
Office	800	840	882	926	972	1,021	1,072	1,126
Telephone	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Interest on LTD	53,744	-49,488	44,115	38,079	31,297	23,676	15,114	5,493
Amortization of grant	0	0	0	0	0	0	0	0
Depreciation	27,440	25,393	23,583	21,972	20,529	19,226	18,043	16,964
	136,084	132,526	128,227	123,606	118,559	112,974	106,733	99,713
INCOME BEFORE TAXES	(80,209)	(73,857)	(66,625)	(58,924)	(50,643)	(41,662)	(31,856)	(21,092)
INCOME TAXES @ 25%	0	0	0	0	0	0	0	0
NET INCOME	($80,209)	($73,857)	($66,625)	($58,924)	($50,643)	($41,662)	($31,856)	($21,092)

IQALUIT GREENHOUSE

VARIABLES
(Unaudited - See Notice To Reader)

OPTION: 7
10,000 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

INFLATION 5%

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
LTD PRINCIPAL	48,900	54,208	60,908	68,437	76,896	86,400	97,079	107,472
LTD INTEREST	67,032	61,724	55,024	47,495	39,036	29,532	18,853	6,854
	115,932	115,932	115,932	115,932	115,932	115,932	115,932	114,326

CAPITAL COST:

BUILDING	458,800
HEAT EXCHANGE	119,000
OTHER EQUIPME	22,500
	600,300

GOVERNMENT GR	0
LONG TERM DEB	600,300
	600,300

REVENUE & EXPENSES - YEAR 1

Lettuce	99,440
Tomato	24,240
Cucumber	14,900
	138,580

Wages and ben	45,000
Growing suppl	3,540
Electricity	33,400
Water	1,825
Oil	0
Repairs and m	2,900
Miscellaneous	1,200
Property taxe	3,500
Professional	1,000
Insurance	3,500
Office	1,000
Telephone	1,200
	98,065

[illegible]

PROJECTED INCOME
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 7
10,000 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
REVENUE								
Lettuce	$89,440	$93,912	$98,608	$103,538	$108,715	$114,151	$119,859	$125,852
Tomato	34,240	35,952	37,750	39,638	41,620	43,701	45,886	48,180
Cucumber	14,900	15,645	16,427	17,248	18,110	19,016	19,967	20,965
	138,580	145,509	152,785	160,424	168,445	176,868	185,712	194,997
Cost of sales								
Wages and benefits	45,000	47,250	49,613	52,094	54,699	57,434	60,306	63,321
Growing supplies	3,540	3,717	3,903	4,098	4,303	4,518	4,744	4,981
	48,540	50,967	53,516	56,192	59,002	61,952	65,050	68,302
Gross margin	90,040	94,542	99,269	104,232	109,443	114,916	120,662	126,695
EXPENSES								
Electricity	33,400	35,070	36,824	38,665	40,598	42,628	44,759	46,997
Water	1,825	1,916	2,012	2,113	2,219	2,330	2,447	2,569
Oil	0	0	0	0	0	0	0	0
Repairs and maintenance	2,900	3,045	3,197	3,357	3,525	3,701	3,886	4,080
Miscellaneous	1,200	1,260	1,323	1,389	1,458	1,531	1,608	1,688
Property taxes	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,926
Professional fees	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Insurance	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,926
Office	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Telephone	1,200	1,260	1,323	1,389	1,458	1,531	1,608	1,688
Interest on LTD	67,032	61,724	55,024	47,495	39,036	29,532	18,853	5,854
Amortization of grant	0	0	0	0	0	0	0	0
Depreciation	32,790	31,046	28,953	27,073	25,374	23,830	22,417	21,119
	149,347	144,771	138,580	131,901	124,610	116,573	107,642	97,663
INCOME BEFORE TAXES	(59,307)	(50,229)	(39,311)	(27,669)	(15,167)	(1,657)	13,020	29,032
INCOME TAXES @ 25%	0	0	0	0	0	0	0	0
NET INCOME	($59,307)	($3?,229)	($39,311)	($27,669)	($15,167)	($1,657)	$13,020	$29,032

IQALUIT GREENHOUSE

PROJECTED CASH FLOW
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 7
10,000 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Net Income	($53,907)	($50,229)	($39,311)	($27,669)	($15,167)	($1,557)	$13,020	$29,032
Amortization	0	0	0	0	0	0	0	0
Depreciation	33,390	31,046	29,953	27,073	25,374	23,830	22,417	21,119
LTD principle	(48,900)	(54,208)	(60,908)	(68,437)	(76,896)	(86,400)	(97,079)	(107,472)
From Operations	($75,417)	($73,391)	($71,266)	($69,033)	($66,689)	($64,227)	($61,542)	($57,321)
Opening cash	0	(75,417)	(148,908)	(220,074)	(289,107)	(355,796)	(420,023)	(481,665)
Closing cash	($75,417)	($148,908)	($220,074)	[illegible]	($355,796)	($420,023)	($481,665)	($538,985)

IQALUIT GREENHOUSE

VARIABLES
(Unaudited - See Notice To Reader)

OPTION: 3
10,000 SQ. FT. - WITHOUT HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

INFLATION %

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
LTD PRINCIPAL	39,208	43,464	48,837	54,873	61,655	69,276	77,838	86,149
LTD INTEREST	53,744	49,488	44,115	38,079	31,297	23,676	15,114	5,493
	92,952	92,952	92,952	92,952	92,952	92,952	92,952	91,642

CAPITAL COST:

BUILDING	458,800
HEAT EXCHANGE	0
OTHER EQUIPME	22,500
	481,300

GOVERNMENT GR	0
LONG TERM DEB	481,300
	481,300

REVENUE & EXPENSES - YEAR 1

Lettuce	89,440
Tomato	34,240
Cucumber	14,900
	138,580

Wages and ben	45,000
Growing suppl	3,540
Electricity	27,500
Water	1,825
Oil	44,600
Repairs and m	2,900
Miscellaneous	1,200
Property taxe	3,500
Professional	1,000
Insurance	3,500
Office	1,000
Telephone	1,200
	136,765

IQALUIT GREENHOUSE

PROJECTED INCOME
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 3
10,000 SQ. FT. - WITHOUT HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
REVENUE								
Lettuce	$89,440	$93,912	$98,608	$103,538	$108,715	$114,151	$1 19,859	$125,852
Tomato	34,240	35,952	37,750	39,638	41,620	43,701	45,886	48,180
Cucumber	14,900	15,645	16,427	17,248	18,110	19,016	19,367	213, 965
	138,580	145,509	152,785	160,424	168,445	176,868	185,712	194,997
Cost of sales								
Wages and benefits	45,000	47,250	49,613	52,094	54,699	57,434	60,306	63,321
Growing supplies	3,540	3,717	3,903	4,098	4,303	4,513	4,744	4,981
	48,540	50,967	53,516	56,192	59,002	61,952	65,050	68,302
Gross margin	90,040	94,542	99,269	104,232	109,443	114,916	120,662	126,695
EXPENSES								
Electricity	27,500	28,875	30,319	31,835	33,427	35,098	36,853	38,696
Water	1,825	1,916	2,012	2,113	2,218	2,330	2,447	2,569
Oil	44,600	46,830	49,172	51,631	54,212	56,924	59,770	62,759
Repairs and maintenance	2,900	3,045	3,197	3,357	3,525	3,701	3,886	4,080
Miscellaneous	1,200	1,260	1,323	1,389	1,458	1,531	1,608	1,688
Property taxes	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,925
Professional fees	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Insurance	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,926
Office	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Telephone	1,200	1,260	1,323	1,389	1,458	1,531	1,608	1,688
Interest on LTD	53,744	49,488	44,115	38,079	31,297	23,676	15,114	5,493
Amortization of grant	0	0	0	0	0	0	0	0
Depreciation	27,440	25,393	23,583	21,972	20,528	19,226	18,043	16,964
	169,409	167,517	164,968	162,195	159,067	155,507	151,393	146,605
INCOME BEFORE TAXES	(79,369)	(72,975)	(65,699)	(57,953)	(49,624)	(40,591)	(30,731)	(19,910)
INCOME TAXES @ 25%	0	0	0	0	0	0	0	0
NET INCOME	($79,369)	($72,975)	($65,699)	($57,953)	($49,624)	($40,591)	($30,731)	($19,910)

IQALUIT GREENHOUSE

PROJECTED CASH FLOW
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 2
10,000 SQ. FT. - WITHOUT HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Net Income	($79,369)	($72,975)	($65,699)	($57,953)	($49,624)	($40,591)	($30,731)	($19,910)
Amortization	0	0	0	0	0	0	0	0
Depreciation	27,440	25,393	23,583	21,972	20,529	19,226	18,043	16,964
LTD principle	(39,208)	(43,464)	(48,837)	(54,873)	(61,656)	(69,276)	(77,838)	(86,149)
From Operations	($91,137)	($91,046)	($90,953)	($90,854)	($90,751)	($90,641)	($90,526)	($89,095)
Opening cash	0	(91,137)	(182,183)	(273,136)	(363,990)	(454,741)	(545,332)	(625, ,908)
Closing cash	($91,137)	($182,183)	($273,136)	($363,990)	($454,741)	($545,392)	($625,90S)	($725,003)

IL! ALUIT GREENHOUSE

OPERATING PROJECTIONS
<Unaudited - See Notice to Reader)

FOR THE FIRST EIGHT YEARS

OFTION B

IQALUIT GREENHOUSE

PROJECTED OPENING BALANCE SHEET
(Unaudited - See Notice To Reader)

ASSETS

FIXED	
Equipment	$22,500
Buildings	458,800
Heat exchange equipment	119,000
	$600,300

LIABILITIES & EQUITY

SHAREHOLDER LOAN	$0
GOVERNMENT RANT	380,000
LONG TERM DEBT	220,300
	$600,300

IQALUIT GREENHOUSE

PROJECTED INCOME
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 7
10,000 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
REVENUE								
Lettuce	$89,440	$93,912	$98,608	%103,538	$108,715	$114,151	$119,859	$125,852
Tomato	34,240	35,952	37,750	39,638	41,620	43,701	4S,886	48,180
Cucumber	14,900	15,645	16,427	17,248	18,110	19,016	19,967	20,965
	138,580	145,509	152,785	160,424	168,445	176,868	185,712	194,997
Cost of sales								
Wages and benefits	45,000	47,250	49,613	52,094	54,699	57,434	60,306	63,321
Growing supplies	3,540	3,717	3,903	4,098	4,303	4,518	4,744	4,981
	48,540	50,967	53,516	56,192	59,002	61,952	65,050	68,302
Gross margin	90,040	94,542	99,269	104,232	109,443	114,916	120,662	126,695
EXPENSES								
Electricity	33,400	35,070	36,824	38,665	40,598	42,628	44,759	46,997
Water	1,825	1,916	2,012	2,113	2,219	2,330	2,447	2,569
Oil	0	0	0	0	0	0	0	0
Repairs and maintenance	2,900	3,045	3,197	3,3s7	3,525	3,701	3,886	4,080
Miscellaneous	1,200	1,260	1,323	1,389	1,458	1,531	1,608	1,688
Property taxes	3,500	3,675	3,8S9	4,052	4,255	4,468	4,691	4,926
Professional fees	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Insurance	3,500	3,675	3,859	4,052	4,255	4,468	4,691	4,926
Office	1,000	1,050	1,103	1,158	1,216	1,277	1,341	1,408
Telephone	1,200	1,260	1,323	1,389	1,458	1,531	1,608	1,688
Interest on LTD	24,599	22,650	20,190	17,427	14,321	10,832	6,911	2,505
Amortization of grant	(21,136)	(19,652)	(18,328)	(17,137)	(16,063)	(15,083)	(14,191)	(13,368)
Depreciation	33,390	31,046	28,953	27,073	25,374	23,830	22,417	21,119
	86,378	86,045	85,418	84,696	83,832	82,790	81,509	79,946
INCOME BEFORE TAXES	3,662	8,497	13,851	19,536	25,611	32,126	39,153	46,749
INCOME TAXES @ 25%	0	0	0	4,185	6,440	8,224	10,050	11,976
NET INCOME	$3,662	$8,497	$13,851	$15,351	$19,171	$23,902	$29,103	$34,773
NET INCOME	$3,662	$8,497	$[3,851	$19,536	$25,611	$32,126	$39,[53	$46,749
Depreciation	33,390	31,046	28,953	27,073	25,374	23,030	22,417	21,119
Amortization	(21,136)	(19,652)	(18,328)	(17,137)	(16,063)	(15,083)	(14,191)	(13,368)
C.C.A.	(26,871)	(20,612)	(14,446)	(11,088)	(9,163)	(7,977)	(7,179)	(6,595)
TAXABLE INCOME	($10,955)	($721)	$10,030	$18,384	$25,759	$32,896	$40,200	$47,905

IQALUIT GREENHOUSE

PROJECTED CASH FLOW
FOR THE FIRST 8 YEARS
(Unaudited -See Notice To Reader]

PTION: 7
10,000SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Net Income	$3,662	$8,497	$13,851	$15,351	$19,171	$23,902	$29,103	$34,773
Amortization	(21,136)	(19,652)	(18,328)	(17,137)	(16,063)	(15,083)	(14,191)	(13,368)
Depreciation	33,390	31,046	28,953	27,073	25,374	23,830	22,417	21,119
LTD principle	(17,953)	(19,902)	(22,362)	(25,12s)	(20,231)	(31,720)	(35,641)	(39,366)
FromOperations	(2,037)	(11)	2,114	162	251	929	1,688	3,158
Opening cash	0	(2,037)	(2,048)	66	220	479	1,408	3,096
Closing cash	(%2,037)	($2,048)	$66	$228	$479	$1,408	$3,096	$6,254

IQALUIT GREENHOUSE

PROJECTED BALANCE SHEET

AS AT YEAREND
(Unaudited -See Notice To Reader)

OPTION: 7
10,000SQ0 FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
ASSETS								
CURRENT								
Cash	($2,037)	($2,048)	$66	$228	$479	$1,408	$3,096	$6,254
FIXED								
cost	600,300	600,300	600,300	600,300	600,300	600,300	600,300	600,300
Accumulated depreciation	(33,390)	(64,436)	(93,389)	(120,462)	(145,836)	(1S9,666)	(192,003)	(213,202)
	566,910	535,864	506,911	479,838	4S4,464	430,634	408,217	387,098
	$564,073	$533,816	$506,977	$480,066	$454,943	$432,042	$411,313	$393,352
LIABILITIES & EQUITY								
SHAREHOLDERS LOAN	$0	$0	$0	$0	$0	$0	$0	$0
GOVERNMENT ASSISTANCE	358,864	339,212	320,884	303,747	287,684	272,601	258,410	245,042
LONG TERM DEBT	202,347	182,445	160,083	134,958	106,727	75,007	39,366	0
RETAINED EARNINGS	3,662	12,159	26,010	41,361	60,532	84,434	113,537	148,310
	$564,873	$533,816	$S06,977	$480,066	$454,943	$432,042	$411,313	$393,3S2

IQALUIT GREENHOUSE

PROJECTED DEPRECIATION
FOR THE FIRST 8 YEARS
(Unaudited -See Notice To Reader)

PTION: 7
10,OOOSQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	cost	Rate	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
ACCOUNTING										
Equipment	$22,500	201	$4,500	$3,600	$2,880	%2,304	$1,843	$1,475	$1,180	$944
Buildings	458,800	5Z	22,940	21,793	20,703	19,660	18,685	17,751	16,863	16,020
	481,300		27,440	2S,393	23,503	21,972	20,528	19,226	18,043	16,964
Heat exchange	119,000	5Z	5,950	5,653	5,370	5,101	4,846	4,604	4,374	4,155
	$600,300		$33,390	$31,046	928,953	$27,073	$25,374	$23,830	$22,417	%21,119
TAX (C.C.A.)										
Equipment	$8,257	201	$826	$1,486	$1,189	$951	$761	$609	$487	$390
Buildings	168,372	5Z	4,209	8,208	7,798	7,40a	7,037	6,686	6,351	6,034
	176,629		5,035	9,694	8,987	8,359	7,79a	7,29s	6,83a	6,424
Heat exchange	43,671	50Z	21,836	10,918	5,459	2,729	1,365	682	341	171
	$220,300		$26,871	$20,612	$14,446	$11,088	$9,163	$7,977	$7,179	$6,S95
GOVERNMENT ASSISTANCE										
Equipment	$14,243	201	$2,849	$2,279	$1,823	$1,458	$1,167	$933	$747	$597
Buildings	290,428	5Z	14,521	13,795	13,106	12,450	11,828	11,236	10,675	10,141
	304,671		17,370	16,074	14,929	13,908	12,995	12,169	11,422	10,738
Heat exchange	75,329	5Z	3,766	3,578	3,399	3,229	3,06a	2,914	2,769	2,630
	$380,000		$21,136	$19,652	$18,328	$17,137	$16,063	$15,083	$14,191	$13,368

Option B

LOAN AMORTIZATION SCHEDULE Oct 11, 1988

Borrower : IQALUIT GREENHOUSE Description : LOAN
Lender : :
Principal: 2?300.00 Payment: 3546.00 payable every 1 month(s)
Interest rate : 12.0000 Compounded every 6 month(s)
Start : 1'38'3/03/ Dst: 1989/03/28 Last: 1997/02/28 Maturity: 1997/02/28

	Date	Interest	Principal	Balance
1.	Mar 28 1989	1907.33	1638.67	218661.22
2.	Apr 28 1989	2133.87	1412.13	~17~4'3.20
3.	May 28 1989	2120.09	1423.91	215823..2.3
4.	Jun 28 1989	2106.18	1439.82	214s83•46
S.	Jul 28 1989	2092.12	1452.88	212929.59
6.	Aug 28 1989	2077.94	1468.06	211461.53
7.	Sep 28 1989	2063.61	1482.39	209979.13
8.	Oct 28 1989	2049.14	1496.86	208482.28
9.	Nov 28 1'38"3	2034.54	1511.46	206'370.81
10.	Dec 28 1989	201'3.79	1526.21	205444.60
11.	Jan 28 1990	2004.8'3	1541.11	203903.4'3
12.	Feb 28 1990	1'38'3.85	1556.15	202347.34
	Sub Total	245'3'3.34	17952.66	
13.	Mar 28 1990	1'374.67	1571.33	200776.01
14.	Apr 28 1990	1959.33	158.5.67	1"3'3189.34
15.	May 28 1990	1943.85	1602.15	1'37587.19
16.	Jun 28 1990	1928.21	1617.7°3	1'35'36'3.40
17.	Jul 28 1990	1912.43	1633.57	194335.83
18.	Aug 28 1990	1896.48	1649.52	1%2686.31
19.	Sep 28 1990	1880.39	1665.61	191020.70
20.	Oct 28 1990	1864.12	1681.87	189338.83
21.	Nov 28 1990	1847.72	1698.28	187640.55
22.	Dec 28 1990	1831.15	1714.85	185925.69
23.	Jan 28 1'3'31	1814.41	1731.5'3	184194.10
24.	Feb 28 1991	17'37•51	1748.49	182445.61
	Sub Total	22650.27	1'3901.73	
25.	Mar 28 15°31	1780.45	1765.55	180680.06
26.	Apr 28 1991	1763.22	1782.78	178897.28
27.	Play 28 19'31	1745.82	1800.18	1770'37.10
28.	Jun 28 1991	1728.25	1817.75	17527'3.36
29.	Jul 28 1991	1710.52	1835.48	172443.87
30.	Aug 28 1991	1692.60	1852.40	1715'30.48
31.	Sep 28 1991	1674.52	1871.48	16'3718.99
32.	Oct 28 1991	1656.25	1889.75	167829.25
33.	Nov 28 19'31	1637.81	1'308.19	165921.06
34.	Dec 28 1991	1619.19	1926.81	163994.25

LOAN AMORTIZATION SCHEDULE Oct 11, 1988

Borrower: IC! ALUI T 13 REENHOUSE Description : LOAN
ender : :
rincipa1 : 220300. 00 Payment : 3546.00 payab 1 e every 1 mont h (s)
Interest rate : 12.0000 Compounded every 6 month (s)
'tart : 1'389/03/01 1st : 1'38'3/(33/'28 last" : 1997 / 02/28 Maturity : 1997/02/28

Date	Interest	Principal	Balance
35. Jan 28 1992	15(>(> . 39	1 '345.61	162048 .63
36. Feb 28 1992	1581. 40	1964.60	16(>(>84 .03
Sub Total	201 90. 42	22361. 58	
37. Mar 28 1992	1562 · 23	1303.77	158100.26
38. Apr 28 1992	1542.87	2003.13	1560'37 .1 3
39. May 28 1992	1523. 32	2022.68	154074.45
40. Jun 28 1992	1323.58	2042 .42	15~03~ . 03
41. Jul 28 1992	1483.65	2062. 35	14'396"3 .68
42. Aug 28 1992	1463. 52	2082 .48	147887.20
43. Sep 28 1992	1442.20	2102.80	145784. 40
44. Oc t 28 1992	1422. 158	21 :3.32	143661.08
45. Nov 28 1992	140 1. 96	2.144.04	141517 ● 04
46. Dec 28 1992	1381.04	2 164. 96	139352.08
47. Jan 28 1993	1359. '31	2186. 0'3	137165. '38
48. Feb 28 1993	1338.57	2207 . 43	134958.56
Sub Tot al	17426.53	25 125. 47	
49. Mar 28 1993	1317.02	2228. '37	13~7~9 .5,3
50. Apr 28 1993	1 295 .28	2250 .7-2	130478.87
51. May 28 1993	1273. 32	2272. 68	128206.19
52. Jun 28 1993	1251.14	2294. 13&	125'31 1.33
53. Jul 28 1993	1228.74	2217.26	1235"34 .07
54. Aug 28 1993	1206 .12	2339 .87	121254·20
55. Sep 28 1993	1183.29	2362.71	1 188'31 . 4'3
56. Oct 28 1993	1160.24	2385.76	116505 .72
57. Nov 28 1993	11 36. 96	2409 .04	1140'36 . 6'3
58. Dec 28 1993	1113.45	2432.55	1 11664.13
59. Jan 28 1994	1(>8'3.71	2456 . 29	10'3207 .84
60. Feb 28 1994	1065.74 "	2480 . 26	106727. S8
Sub Total	14221.02	28230 .98	
61. Mar 28 1994	1041.53	2504.47	104223.11
62. Apr 28 1994	1017.09	2528.51	101694.20
63. May 28 1994	992.41	2553 .59	99140. 61
64. Jun 28 1994	967.49	2578.51	96562.11
65. Jul 28 1994	942.32	2603.67	93958 .44

IQALUIT GREENHOUSE

PRINCIPAL ASSUMPTIONS TO PROJECTIONS

FOR THE FIRST EIGHT YEARS

(Unaudited - See Notice to Reader)

1. Revenue and expense amounts have been estimated by project management for year 1. Thereafter, these estimates are increased 5% per year for inflation.

2. Depreciation has been provided by the declining balance method at the rates set out in the projected depreciation statement.

3. Amortization of Government Assistance has been provided by the declining balance method at the rates the assets qualifying for the assistance are being depreciated, and are set out in the projected depreciation statement.

4. Revenue and expense amounts are assumed to be received and paid in the year incurred.

5. Accelerated capital cost allowance for income tax purposes has been used for the heat exchange equipment. It is necessary for the Minister of Energy, Mines and Resources to certify the equipment to qualify for the accelerated rate.

IQALUIT GREENHOUSE

PROJECTED INCOME
FOR THE FIRST 8 YEARS
(Unaudited See Notice To Reader)

OPTION: 7
10,OOOW FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
REVENUE								
Lettuce	$89,440	$93,912	098,608	$103,538	$108,11s	8114,1s1	$119,859	$125,852
Tomato	34,240	3s,9s2	31,150	39,636	41,620	43,701	45,886	48,160
Cucumber	14,900	1s,645	16,427	17,240	18,110	19,016	19,967	20,%s
	138,s60	14s,s09	152,785	160,424	168,445	176,868	18s,712	194,997
Cost of sales								
Wages and benefits	57,000	59,850	62,843	63,98S	69,264	72,748	76,36S	80,204
Growing supplies	3,540	3,717	3,903	4,096	4,303	4,518	4,744	4,981
	60,340	63,S67	66,746	70,083	73,587	77,266	81,129	85,185
Gross margin	10,046	81,942	86,039	90,341	94,858	99,602	104,s83	109,812
EXPENSES								
Electricity	33,400	35,070	36,824	38,665	40,598	42,628	44,739	46,997
Water	1,825	1,916	2,012	2,113	2,219	2,330	4447	2,S69
011	0	0	0	0	0	0	0	0
Repairs and maintenance	2,900	3,04$	3,197	3,3s7	3,S2S	3,701	3,666	4,080
Miscellaneous	1,200	1,260	1,323	1,389	1,458	1,531	1,608	1,688
Property taxes	3,s00	3,67S	3,859	4,0s2	4,25S	4,468	4,691	4,926
Professional fees	1,000	1,0s0	1,103	1,158	1,216	1,277	1,341	1,408
Insurance	3,s00	3,675	3,839	4,052	4,255	4,468	4,691	4,926
Office	1,000	1,050	1,103	1,1s8	1,216	1,277	1,341	1,408
Telephone	1,200	1,260	1,323	1,389	1,458	1,531	1,608	1,688
Interest on LTD	17,900	16,482	14,692	12,682	10,422	7,064	5,032	1,827
Amortization of grant	(18,912)	([7,583)	(16,398)	(1s,334)	(14,372)	(13,491)	(12,696)	(11,961)
Depreciation	33,390	31,046	28,933	21,073	2s,374	23,830	22,417	21,119
	81,903	81,946	81,8S0	81,754	81,624	81,428	81,125	00,67S
INCOME BEFORE TAXES	(3,863)	(4)	4,189	8,587	13,234	18,174	23,458	29,137
INCOME TAXES @ 25%	0	0	0	0	0	1,840	6,174	7,626
NET INCOME	($3,863)	($4)	$4,109	$8,587	$13,234	$16,334	$17,284	$21,s11
NET INCOME	($3,863)	($4)	$4,189	$8,587	$13,234	$18,174	$23,458	$39,137
Depreciation	33,390	31,046	28,9s3	27,073	25,374	23,830	22,417	21,119
Amortization	(18,912)	(17,583)	(16,398)	(1s,334)	(14,372)	(13,497)	(12,696)	(11,961)
C.C.A.	(31,1s1)	(24,334)	(11,069)	(13,102)	(10,827)	(9,424)	(8,483)	(7,791)
TAXABLE INCOME	($21,1361	($10,695)	($325)	$7,224	$13,409	$19,083	$24,696	*30,504

IQALUIT GREENHOUSE

PROJECTED CASH FLOW
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

IP110N: 1
10,000SQ FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Net Income	($3,963)	($4)	$4,189	$8,587	$13,234	$16,334	$17,284	$21,511
Amortization	(18,912)	(17,s83)	(16,398)	(1s,334)	(14,372)	(13,497)	(12,696)	(11,961)
Depreciation	33,390	31,0'4s	28,953	27,073	23,314	23,830	22,417	21,119
LID principle	(13,060)	(14,478)	(16,260	(18,27S)	(20,S38)	(23,0161	(2s,928)	(28,674)
From Operations	(2,445)	(1,019)	416	2,048	3,698	3,s91	1,077	1,99s
Opening cash	0	(2,44s)	(3,464)	(2,988)	(940)	2,758	6,349	7,426
Closing cash	($2,44S)	(43,464)	($2,930)	($940)	$2,758	$6,349	$7,426	$9,421

IQALUIT GREENHOUSE

PROJECTED BALANCE SHEET

AS AT YEAR END
(Unaudited - See Notice To Reader)

OPTION: 7
10,000 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
ASSETS								
CURRENT								
Cash	($2,445)	($3,464)	($&90a)	($940)	$2,758	$6,349	$7,426	$9,421
FIXED								
cost	600,300	600,300	600,300	600,300	600,300	600,300	600,300	600,300
Accumulated depreciation	(33,390)	(64,436)	(93,389)	(120,462)	(145,836)	(169,6661	(192,083)	(213,2021
	366,910	S3S,864	506,911	479,630	434,464	430,634	400,217	387,098
	$564,46S	4332,400	4303,923	$410,898	$437,222	$436,903	$415,643	$396,519

LIABILITIES & EQUITY

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8
SHAREHOLDERS LOAN	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000	$100,000
GOVERNMENT ASSISTANCE	321,088	303,S05	287,107	271,773	2S7,401	243,904	231,200	219,247
LONG TERM DEBT	147,240	132,762	116,494	90,216	77,678	54,602	28,614	0
RETAINED EARNINGS	(3,863)	(3,867)	322	0,909	22,143	38,477	33,761	77,272
	$S64,463	$S32,400	$503,923	$478,6%	$457,222	$436,983	$415,643	$396,519

Borrower II C! ALUIT 13? EENHOUSE Description :LOAN
Lender :
Principal : 160300. 00 Payment: 2380.00 payable every 1 month(s)
Interestrate : 12.0000 Compounded every 6 month(s)
Start : 1989/03/01 1st :1989/03/28 Last : 1997/02/28 Maturity :1997/02/28

Date	Interest	Principal	Balance
35. Jan 28 1992	1164.60	1415, 40	117323.11
36. Feb 28 1992	1150. 73	1429.21	116433.30
Sub Total	14692.34	16267,66	
37. Mar 28 1992	1136.84	1443.16	115050,74
38. Apr 28 1992	1122.76	1457,24	113593.50
39. May 28 1992	1108.54	1471.46	112122,03
40. Jun 28 1992	1094. 18	1485.82	110636.21
41. Jul 28 1992	1079. 68	1500.32	109133.80
42. Aug 28 1992	1065. 03	1514.97	107620.92
43. Sep 28 1992	1030.25	1529. 75	106031,17
44. Oct 28 1992	1035.32	1344.68	104546.49
45. Nov 28 1992	1020.25	1559. 75	102986.74
46. Dec 28 1992	1005.03	1574. 97	101411.76
47, Jan 28 1993	983 .66	1590. 34	99821.42
48. Feb 28 1993	974.14	1605.86	98215.56
Sub Total	12681.56	10278.34	
49. Mar 20 1993	958,47	1621.53	96594.02
50. Apr 28 1993	942.64	1637.36	94956.66
51. May 28 1993	926.66	1653.34	93303,33
52. Jun 28 1993	910.53	1669.47	91633.85
53. Jul 28 1993	894.24	1689.76	89948.09
54. Aug 28 1993	877.78	1702.22	88245.88
55. Sep 28 1993	861.17	1710.83	86527.05
56. Oct 28 1993	844.40	1735 .60	84791.45
57. Nov 28 1993	827. 46	1752. 54	83038.91
58. Dec 28 1993	810.36	1769.64	81269.27
59. Jan 28 1994	793. 09	1786.51	79482.36
60. Feb 28 1994	775.65	1804.35	77678.01
Sub Total	10422.45	20537, 55	
61, Mar 28 1994	758.04	1821.96	75856.06
62. Apr 28 1994	740.26	1839.74	74016.32
63. May 28 1994	722.31	1857 .69	72158.63
64. Jun 28 1994	704.18	1875. 82	70282.81
65. Jul 28 1994	685,88	1894. 12	68388.69

IQALUIT GREENHOUSE

PROJECTED DEPRECIATION
FOR THE FIRST 8 YEARS
(Unaudited - See Notice To Reader)

OPTION: 7
10,000 SQ. FT. - WITH HEAT EXCHANGE EQUIPMENT 12 MONTH SEASON

	Cost	Rate	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
ACCOUNTING										
Equipment	$22,300	20%	$4,500	$3,600	$2,880	$2,304	$1,843	$1,475	$1,180	$944
Buildings	438,000	5%	22,940	21,793	20,703	19,668	18,685	17,751	16,863	16,020
	481,300		27,440	25,393	23,583	21,972	20,528	19,226	18,043	16,964
Heat exchange	119,000	5%	3,950	5,653	5,370	5,101	4,846	4,604	4,374	4,155
	$600,300		$33,390	$31,046	$28,953	$27,073	$23,374	$23,830	$22,417	$21,119
TAX (C.C.A.)										
Equipment	$9,756	20%	$976	$1,756	$1,405	$1,124	$899	$719	$575	$460
Buildings	190,943	5%	4,974	9,698	9,214	8,753	8,315	7,899	7,505	7,129
	208,699		5,950	11,454	10,619	9,877	9,214	8,618	8,080	7,589
Heat exchange	51,601	30%	23,801	12,900	6,450	3,225	1,613	806	403	202
	$260,300		$31,751	$24,354	$17,069	$13,102	$10,827	$9,424	$8,483	$7,791
GOVERNMENT ASSISTANCE										
Equipment	$12,744	20%	$2,549	$2,039	$1,631	$1,305	$1,044	$835	$668	$533
Buildings	259,857	5%	12,993	12,343	11,726	11,140	10,583	10,054	9,551	9,073
	272,601		15,542	14,382	13,357	12,445	11,627	10,889	10,219	9,608
Heat exchange	67,399	5%	3,370	3,201	3,041	2,889	2,743	2,608	2,477	2,353
	$340,000		$18,912	$17,583	$16,398	$15,334	$14,372	$13,497	$12,696	$11,961

LOAN AMORTIZAT ION SCHEDULE Oct 25, 1988

Borrower : IQALUIT GREENHOUSE Description :LOAN
Lender : :
Principal : 160300 .00 Payment : 2580.00 payable every 1 month(s)
Interest rate : 12.0000 Compounded every 6 month(s)
Start : 158'3/W/01 1st :1989/03/28 Last : 1997/02/28 Maturity : 1'3'37/02/28

Date	Interest	Principal	Balance
66, Aug 28 1994	6647.33	1'3 12.61	66476.08
67. Sep 28 1994	648073	1'331.27	64544.80
68 . Oct 28 1994	629.88	i 950.12	6'25'34. 68
69. Nov 28 1994	610.85	1969.15	60625.53
70. Dec 28 1994	531.63	1988.37	58637.16
71. Jan 28 1995	S72. 23	2007.77	56629.39
72. Feb 28 13'35	552.63	2027,37	54602.03
Sub Total	7004,01	23075.99	
73. Mar 28 1995	532.85	2047.15	52554.88
74. Apr 28 1995	512.87	2067.13	50487.7s
7S. May 28 1995	492.70	2007.30	48400.4s
76. Jun 28 1995	472.33	2107.67	46292.78
77. Jul 28 1995	451 .76	2128.24	44164.54
70. Aug 28 1995	430.99	2149.01	42013.53
79. Sep 28 1995	410.02	216'3. 98	39845.55
80. Oct 28 1995	38s. 84	2191.16	37654.40
81. Nov 28 1995	367. 46	2212. 54	35441. 86
82. Dec 28 1995	345.87	2234.13	3wiw7• 73
83. Jan 28 1996	324 .07	22s5. 93	30951.80
@+. Feb 28 1996	302. 05	2277.95	2S673, 85
Sub Total	5031 .82	2s928 . i 8	
85. Mar 28 1996	27'3.82	2300.18	26373.67
86. Apr 28 1996	257.3a	2322.62	24051, 05
87. May 28 1996	234.71	2345.29	21705.76
88. Jun "28 1996	21 i .82	2368.i 8	19337, 58
89. Jul 28 1996	188.71	2391. 29	16346.23
90. Aug 28 1996	165.38	2414.62	14531,66
'31. Sep 28 1'3'36	14 i .81	2438.19	12053.48
92. Oct 28 1996	118.02	246 i .'38	9631● 43
93. Nov 28 1996	93. 99 .	2486.01	7145.49
94. Dec 28 1996	69.73	25i0.27	4635 .2.2
95. Jan 28 1997	45.23	2534 . 77	2100.45
96. Feb 28 1997	20,50	2559.50	-4s9.03
Sub Total	1s27. 10	29132.90	