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SOLERAS

Solar Controlled Environment Agriculture Project

FINAL REPORT

Volume 9
Science Applications, Incorporated
Phase 2 - Definition Study

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Midwest Research Institute, Operating Agent

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FOREWORD

THE SOLERAS PROGRAM: A UNIQUE EFFORT IN COOPERATIVE SOLAR ENERGY RESEARCH

In October 1977, Saudi Arabia and the United States signed a Program Agreement for Cooperation in the Field of Solar Energy. The Program, named SOLERAS, is the first of its kind in purpose, funding, organization, and results. It is based on the respective commitments of the United States and Saudi Arabia to advance the development of solar energy as a viable cost-competitive energy alternative, by combining the technical and other unique resources of each country. SOLERAS has made significant progress in demonstrating the effectiveness of solar energy—progress that would have been difficult for either country to achieve on its own.

SOLERAS is sponsored by the government agencies responsible for energy research and development in each country: the Saudi Arabian National Center for Science and Technology (SANCST) and the United States Department of Energy. The Program is under the auspices of the United States-Saudi Arabian Joint Commission on Economic Cooperation, formed in 1974 by the Saudi Arabian Ministry of Finance and National Economy and the United States Department of the Treasury.

Although SOLERAS is only one of more than 30 such projects under the direction of the Joint Commission, it is the only one that is funded by both countries. All other projects are funded completely by Saudi Arabia. This jointly funded program is evidence, therefore, that both countries recognize the mutually beneficial results expected to be generated by the cooperative research projects undertaken by SOLERAS.

The administration of SOLERAS also reflects the philosophy of cooperation underlying this unique Program. Senior officials from SANCST, the Ministry of Finance and National Economy, the U.S. Department of Energy, and the U.S. Department of the Treasury comprise an eight-member Executive Board which governs all aspects of the SOLERAS Program. The Board establishes the goals, objectives, and policies of SOLERAS and oversees the technical and financial management of the projects undertaken to implement those goals and objectives.

A four-member Project Selection Committee, with two members from each government, assists the Executive Board in selecting and evaluating projects. Its members combine their technical expertise and experience in renewable energy technologies and demonstration projects to review proposals, designs, plans, reports, operations, and data for the various projects.

The daily technical and administrative management of the SOLERAS projects is the responsibility of Midwest Research Institute, an independent, not-for-profit research organization, which has been designated as the SOLERAS Operating Agent. MRI utilizes technical and managerial personnel from both countries in fulfilling its responsibility for implementing the decisions of the Executive Board and in managing the individual technical projects. This includes contracting with various companies and research organizations in both countries to design and install state-of-the-art solar systems. SOLERAS program offices are located at MRI's Kansas City, Missouri, headquarters, and in Riyadh and Yanbu, Saudi Arabia.

SOLERAS has initiated several major research projects: converting solar energy into electricity for everyday use by the inhabitants of several rural villages; testing solar energy as a source for space cooling and water treatment; developing agricultural systems using solar energy to control the entire growing environment; undertaking fundamental photovoltaic and solar thermal research; establishing high technology laboratories for advanced solar research at Saudi Arabian universities; and sponsoring basic solar energy research in universities in the United States.

In addition, SOLERAS has contributed to the dissemination of scientific and technical solar information through its sponsorship of technology workshops, short courses, and the publication of technical reports. These have provided an important means of informing the scientific research community about the solar energy technologies developed under SOLERAS and other relevant projects throughout the world.

تقديم

«البرنامج السعودي الأمريكي المشترك» للتعاون في ميدان أبحاث الطاقة الشمسية

وقعت المملكة العربية السعودية والولايات المتحدة الأمريكية في عام ١٩٧٧م اتفاقية برنامج التعاون في ميدان أبحاث الطاقة الشمسية . وكان هذا البرنامج الذي سُمي «سوليراس» الأول من نوعه من حيث الغرض والتمويل والتنظيم والنتائج . وهو معتمد على الالتزام المتبادل بين الولايات المتحدة الأمريكية والمملكة العربية السعودية بالعمل على تنمية الطاقة الشمسية ، بوصفها طاقة بديلة متجددة وذات كلفة منافسة ، عن طريق الجمع للموارد الفنية وغيرها من المصادر الطبيعية لكل من البلدين . ولقد حقق برنامج «سوليراس» تقدماً ملحوظاً ببيان فعالية الطاقة الشمسية ، وهو تقدم قد يكون من الصعب تحقيقه على أي من البلدين منفرداً .

يتم انجاز برنامج «سوليراس» تحت رعاية الهيئات الحكومية المسؤولة عن أبحاث وتنمية الطاقة في كل من البلدين ، أي المركز الوطني السعودي للعلوم والتكنولوجيا ووزارة الطاقة الأمريكية . وتشرف على البرنامج اللجنة الأمريكية السعودية المشتركة للتعاون الاقتصادي المكونة عام ١٩٧٤م من قبل وزارة المالية والاقتصاد الوطني في المملكة العربية السعودية ووزارة المالية في الولايات المتحدة الأمريكية .

بالرغم من أن برنامج «سوليراس» هو واحد من بين ما يزيد عن ٣٠ مشروعاً تديرها اللجنة المشتركة فإنه البرنامج الوحيد الذي يموله البلدان ، في حين أن جميع البرامج الأخرى تمولها المملكة العربية السعودية كلياً . فيبرهن هذا البرنامج ، المشترك التمويل ، على أن كلا البلدين يعترفان بالفوائد المتبادلة المتوقعة تحقيقها من خلال مشاريع البحث التعاوني التي يتداولها برنامج «سوليراس» .

وتعكس إدارة «سوليراس» أيضاً فلسفة التعاون التي يستند عليها هذا البرنامج . فيشكل مسؤولون من المركز الوطني السعودي للعلوم والتكنولوجيا ومن وزارة المالية والاقتصاد الوطني ومن وزارة الطاقة الأمريكية ووزارة المالية الأمريكية مجلساً تنفيذياً يضم ثمانية أعضاء ويدير جميع جوانب برنامج «سوليراس» . فيحدد هذا المجلس أهداف وغايات وسياسة «سوليراس» كما يشرف على الإدارة الفنية والمالية للمشاريع المباشرة لتحقيق هذه الأهداف والغايات .

تقوم لجنة اختيار المشاريع المكونة من أربعة أعضاء ، اثنان من كل جانب بمساعدة المجلس التنفيذي في اختيار وتقييم المشاريع . فيجمع أعضاء هذه اللجنة خبرتهم الفنية وتجربتهم في مجال تكنولوجيا الطاقة المتجددة والمشاريع النموذجية لمراجعة المقترحات والتصاميم والمخططات والتقارير والعمليات والبيانات المتعلقة بالمشاريع المتنوعة .

أما الإدارة الفنية والإدارية اليومية لمشاريع «سوليراس» فهي تحت مسؤولية «مدوست ريسيرتش انستيتوت» (معهد «مدوست» للأبحاث) . وهو معهد أبحاث مستقل ليس ذا صبغة تجارية ، تم تعيينه كوكيل تشغيل لبرنامج «سوليراس» . ويستخدم معهد «مدوست للأبحاث» فنيين وإداريين من كلا البلدين للقيام بمسؤولية تنفيذ قرارات المجلس التنفيذي وإدارة المشاريع الفنية الفردية . ويشمل ذلك التعاقد مع مختلف الشركات ومعاهد الأبحاث في كلا البلدين لتصميم وتركيب أنظمة طاقة شمسية من أحدث تكنولوجيا . وتقع مكاتب برنامج «سوليراس» في المقر الرئيسي لمعهد «مدوست للأبحاث» بمدينة كنساس سيتي بولاية ميزوري وكذلك في الرياض وينبع بالمملكة العربية السعودية .

انبعث من برنامج «سوليراس» العديد من مشاريع الأبحاث الكبرى ، منها تحويل الطاقة الشمسية الى كهرباء للاستعمال اليومي لسكان العديد من القرى الريفية واختبار الطاقة الشمسية كمصدر طاقة للتبريد والتدفئة وتحلية المياه وتطوير أنظمة زراعية باستعمال الطاقة الشمسية للتحكم في كامل بيئة الانماء ، والقيام بأبحاث نظرية حول الخلايا الكهروضوئية والحرارة الشمسية وانشاء مختبرات تكنولوجيا عالية للأبحاث الشمسية المتقدمة في الجامعات السعودية ورعاية أبحاث أساسية في الطاقة الشمسية في جامعات بالولايات المتحدة الأمريكية .

كما أن برنامج «سوليراس» ساهم في نشر المعلومات العلمية والفنية المتعلقة بالطاقة الشمسية من خلال رعايته للندوات العلمية والدورات القصيرة ونشر التقارير الفنية . ولقد كان ذلك وسيلة لنقل معلومات هامة لمجموعة الباحثين العلميين حول تكنولوجيا الطاقة الشمسية المطورة من خلال برنامج «سوليراس» والمشاريع الأخرى المرتبطة به عبر بلدان العالم .

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ABSTRACT

This report describes the effort required to implement the design of the Solar Controlled Environment Agriculture Engineering Test Facility, SCEA-ETF, as described in the Task 4 Report, which consisted principally of drawings and specifications. This report is a basic blueprint for the Phase 2 activities which have as a goal the construction of the ETF. These activities have been broken down into five major tasks, namely Project Management; Engineering and Design; Procurement/Fabrication; Construction, Installation and Checkout; and Operation & Maintenance. The type of activities required under each of these tasks are described followed by a detailed work breakdown structure. The Phase 2 project organization is discussed, and is largely the same as the one for Phase 1. A 13 month schedule for the total project is also given. Lastly, two appendices discuss cost adjustment factors for an ETF located in the KSA, and an update of the commercial system cost estimate based on preliminary cost quotations for the ETF. The results show a 63% cost increase for the KSA ETF primarily due to higher construction costs and greater well depth. The commercial system cost required an adjustment upwards of 7.7%.

SECTION 1

INTRODUCTION

This report describes the results of the Task 5 effort of the project described in the Preface. The objective of Task 5 is to put into perspective the preliminary design defined in Task 4 and to prepare an action plan for its implementation and operation. In addition, the economic viability of engineering field test facilities for other sites in both the United States and the Kingdom of Saudi Arabia are to be evaluated. The principal effort under this task is to define the cost, schedules and operational requirements necessary to successfully put into operation the Engineering Field Test Facility defined under Task 4. To accomplish this the following specific items will be discussed for the facility which is to be constructed in El Paso, Texas.

- Detailed Engineering and Design
- Procurement, Fabrication/Construction, and Installation Plans
- Operation and Maintenance Plans
- Training Plans
- Environmental Assessment Plan
- Test Plans
- Cost and Economic Analyses

Once all the information has been developed for the El Paso site an assessment is made for similar facilities installed in Saudi Arabia. The results of this assessment is reported in terms of changes in construction, operation and cost compared to the El Paso, Texas system.

The Engineering Field Test Facility shown as an artist conception in Figure 1-1 consists of a 0.36 hectare greenhouse complex designed for the enhanced growth of vegetables. The fresh water needs of the facility are provided by a reverse osmosis (RO) desalination system using brackish aquifer water with 3500 mg/l total dissolved solids (TDS). All of the power needs of the greenhouse and desalination facility are provided by solar energy; the support facilities will be connected to the local utility grid.

Figure 1-1. Overall View of the ETF

The greenhouse employs an innovative roof-filter/fluid-roof concept which utilizes an inner roof glazing which selectively allows sunlight in the 400-700nm range to pass into the greenhouse but strongly absorbs sunlight outside this range. The absorbed infrared radiation heats the inner glazing. This heat is removed by water sprayed onto the upper portion of the glazing and collected by a gutter system at its lower edges. In order to isolate the roof water from the environment and to provide some insulation to the greenhouse, an air inflated durable clear plastic with a high transmissivity is used to cover the inner glazing. The heated roof water is returned to an underground storage tank. In the summertime, when the roof has to be cooled, water from a storage tank is pumped through a heat exchanger where its temperature is reduced by 18°C ground water. In wintertime, the excess energy is collected in the storage tank and is used to provide nighttime heating of the greenhouse, if required. The 18°C ground water source can be used to augment the heating requirement. The primary function of the fluid-roof/roof-filter is to prevent harmful infrared radiation from entering the greenhouse and from being absorbed by the plant foliage. In this manner plant foliage and greenhouse air temperatures are nearly identical, plant evapotranspiration losses are minimized, and plant foliage is more nearly at its optimum growth temperature. Because of the lower evapotranspiration losses fan power requirements to control humidity are significantly reduced.

Greenhouse dehumidification is accomplished by means of cool aquifer water and activated during the daylight hours only. Water condensed in this process is recycled back into the greenhouse. The greenhouse enveloped has been designed in such a way as to minimize air infiltration. Such tight construction maximizes the water recovered from the dehumidification process, and makes feasible carbon dioxide (CO₂) enrichment. It has been estimated that a sustained greenhouse CO₂ level of 1000 ppm during daylight hours enhances the productivity by at least a factor of two over ambient air CO₂ levels (325 ppm). Therefore, a liquid CO₂ storage facility has been included in the design so that CO₂ levels of approximately 1000 ppm can be maintained during the daylight hours. There are times when the greenhouse air temperature is too low to effectively control humidity (such as during wintertime or early morning hours). In these circumstances, outside air in just the needed proportion is allowed into the greenhouse. If the air exchange rate is not too great the CO₂ injection is continued, otherwise it is inhibited.

The layout of the greenhouse complex is shown in Figure 1-2. The greenhouse itself is basically square with four square growing compartments separated by a corridor running North-South. Outside the East side and West side of the greenhouse are two large storage tanks totaling 36.5 m³ which contain the roof cooling/heating water. This water must be purified by a demineralizer to a TDS of approximately 3 ppm to prevent scale build up on the glass. The corridor is used as a main corridor for access to all growing sections and houses materials needed for direct support of the growing operations as well as other growing area mechanical/electrical equipment. An indirect support facility housing such items as fertilizer, fresh produce, RO system, office space, control room, batteries, etc. is located at the North end of the greenhouse.

The greenhouse growing media is a 30 cm layer of porous sand situated on top of a sloped floor, covered with a plastic liner. Embedded in the sand are drainage pipes which allow excess fertigation water to be leached and which are used for periodic purging of the soil to prevent salt buildup. The leachate is collected in a holding pond along with a portion of the rainwater and is subsequently used to irrigate outside vegetation. Crop residue is taken outside, tilled into the soil, and allowed to compost, thereby improving the quality of the soil and allowing for the possibility of growing marketable products outside the greenhouse.

The desalination system consists of pretreatment and RO subsystems. Fresh water produced by the RO system which will have a TDS of less than 250 ppm is stored in a 23 m³ fresh water tank. During plant startup water from the fresh water tanks are sent through a demineralizer reducing the TDS to approximately 3 ppm before entering roof water storage. During greenhouse operation the demineralizer will be used to maintain the roof water at the required 3 ppm purity. Waste water from the RO and demineralizer systems are pumped to a nearby drainage canal after mixing with aquifer cooling/dehumidification water.

The energy system consists of 37.7 kWp of photovoltaic modules, 88 kWh of battery storage, and a 37 kW power conditioning unit. Backup power is provided by the local electric utility instead of diesel generators.

Figure 1-2. Site Plan of the ETF

The control system controls the entire facility from a centrally located point. In many cases, however, individual subsystems have their own integral controls in which case the central control system is only used to monitor these systems, to sound alarms, and to activate or deactivate the system.

Each of the four growing areas will be operated and controlled individually. This procedure provides for increased facility reliability as well as for maintaining separate environmental conditions.

The support building is a prefabricated steel building with a floor area of approximately 465 m^2 (5000 ft^2) and houses the offices, sanitary facilities, water treatment equipment, shop and workspaces, electrical equipment, control room, and storage areas.

Table 1-1. Summary of System Key Features

Major System Element	Key Features
Greenhouse	● Fluid Roof ● 0.36 Ha Growing Area ● Four Growing Compartments ● CO₂ Supplementation ● Dehumidification/Water Recovery ● Leaf Temperature Control ● Efficient Central Access Corridor ● Sand Growing Medium
Desalination	● 75% Recovery ● 10 m³/day Capacity ● 1.51 kWh/m³ Energy Consumption ● Spiral Wound Membrane ● Pretreatment ● Automatic Operation
Energy	● PV Output 37.7 kWp ● Battery Capacity 88 kWh ● Output Proportional to Demand ● High Part Load Power Conditioner/Inverter Efficiency ● Utility Power as Backup
Control	● Fully Automatic Control ● Alternate Manual Central Station Control ● Backup Manual Control from Greenhouse ● Redundant Processor-Independent Alarms ● Integral Data Acquisition System
Support	● Efficient Physical Layout ● Summer Cooling by Reject CO₂ "coolness" ● Ample Office, Lab, Storage, Work and Rest Areas
Wells	● Multiple Groundwater Wells ● 99.95% of Water Withdrawn Returned to Aquifer

SECTION 2

WORK PLAN

The successful implementation of the SCEA Engineering Test Facility developed under Task 4 through a detailed system design and subsequent construction and operation requires careful planning and a detailed definition of the requirements. The work plan described in this section starts with the development of a detailed work breakdown structure followed by the development of a schedule. The cost estimate for implementing the proposed design will be provided as a separate volume. The timely completion of all activities is monitored by our project control system.

GENERAL BREAKDOWN OF WORK

The proper definition of a Work Breakdown Structure, (WBS), is the key to the success of the project. Considerable attention has therefore been directed toward the development of a sufficiently detailed WBS to ensure that all labor and schedule items can be identified readily. The WBS is the framework for our cost estimates. The WBS is based on the division of the engineering field test facility into a number of physical land areas that can be identified on a plot plan. Within the boundaries of these areas specific subsystems are identified and for which the required effort has been broken down into four functional tasks:

- Engineering and Design
- Procurement/Fabrication
- Construction/Installation and Checkout
- Operation and Maintenance.

These four functional tasks are coordinated by Project Management. These five items can then be defined as five tasks as shown in Figure 2-1.

As shown in Figure 2-1 each task is made up of work items that may be considered subtasks. Overlap and the iterative nature of these items makes it difficult to consider these as separate subtasks. The next section describes in generic

FIGURE 2-1. PHASE 2 BREAKDOWN OF WORK

terms the effort generally required under each task, followed by a detailed WBS. The scope of effort under each task is described below in some detail.

Task 1 - Project Management

The overall management approach entails the definition and administration of a plan comprising all functions essential to successfully execute the project. Program management involves the control of cost, schedule and quality of performance in each of the three key areas of system deployment, namely: system design, implementation, and evaluation. The principal activities are shown schematically in Figure 2-2. The detailed activities to be accomplished under Phase 2 and Phase 3 are shown in Figures 2-3 through 2-5. Management must ensure that each activity be accomplished with full cognizance of its impact on all other activities if the system is to be fully responsive to the project requirements and if it is to be deployed within performance and cost specifications.

To meet the management requirements stated above, it is essential that, as a starting point, the management develop a Program Plan which should be updated during the course of this project when deviations and/or modifications of the key decision points outlined in the initial plan are warranted. The Program Plan must provide a clear view of the progress accomplished, funds expended, accomplishments required and personnel required during the following stated period.

The key requirements of the program plan are:

- To incorporate the significant activities from Figures 2-3 through 2-5 into a Work Breakdown Structure (WBS), schedule and cost objectives by specific WBS elements.
- To provide checkpoints for review and reporting of progress as well as deviations.
- To provide procedures for control of schedule, performance and cost, and for implementing corrective actions warranted should significant deviations from the plan occur.
- To identify key organizational responsibilities down to the task leaders.

FIGURE 2-2. SYSTEM DESIGN, IMPLEMENTATION & EVALUATION PROCESS FLOW

DETAILED COMPONENT AND SUBSYSTEM SPECIFICATIONS

COLLECTOR FIELD — PV MODULES, PV ARRAY, SUPPORT RACK, FOUNDATIONS, CABLING, INSTRUMENTATION
ELECTRICAL STORAGE — BATTERIES, SUPPORT RACKS, CABLING, INSTRUMENTATION, SAFETY
GREENHOUSE ENVELOPE — FOUNDATIONS, SUPPORT COLUMNS, TRUSSES, GLASS ROOF, PLASTIC FILM ROOF
SPACE CONDITIONING — AIR HANDLERS, HEAT EXCHANGES, VENTILATION FANS, PUMPS, VALVES, PIPING
SITE DEVELOPMENT — UTILITIES, GRADING, GENERAL ARRANGEMENT, WELLS
METEOROLOGICAL STATION — PYRHELIOMETER, PYRANOMETER, THERMOMETER, ANEMOMETER
DESALINATION SYSTEM — PRETREATMENT, REVERSE OSMOSIS, DEMINERALIZER
CONTROL SYSTEM — CONTROL PANELS, COMPUTER, DATA ACQUISITION, DISPLAYS, INSTRUMENTATION
MISCELLANEOUS — CO2 GENERATOR, WELL PUMPS, PRODUCE STORAGE
FACILITY INTEGRATION — HOUSINGS AND ENCLOSURES, ELECTRICAL SYSTEMS, SERVICE EQUIPMENT

IMPLEMENTATION FUNCTIONS

BUDGET — COSTING OF SYSTEM, SUBSYSTEMS AND COMPONENTS
MANAGEMENT PLAN — CONSTRUCTION, SYSTEM INTEGRATION, MANPOWER, COST CONTROL
SEQUENCE AND SCHEDULES — HARMONIZE WITH OTHER CONSTRUCTION PLANNED OR IN-PROGRESS
QA/QC PROCEDURES — SYSTEM AND COMPONENT ACCEPTANCE CRITERIA, TESTS, AND SCHEDULES
SYSTEM CHECKOUT PROCEDURES — PRELIMINARY OPERATION, MAINTENANCE, AND TRAINING MANUALS

FIGURE 2-3. DETAILED DESIGN

FIGURE 2-4. PROCUREMENT, CONSTRUCTION AND INSTALLATION

- REVIEW OF T&E CRITERIA FOR ACCEPTANCE
- DEFINITION OF T&E PROCEDURES (CONCURRENT WITH DETAILED DESIGN PHASE)
  - METHODS, TYPES OF TEST AND SEQUENCE
  - ACCESS POINTS
  - INSTRUMENTATION
    - CONTROL, OPERATION AND MAINTENANCE, SAFETY
    - DATA ACQUISITION
    - DISPLAYS
    - CALIBRATION TOLERANCES, SCHEDULE AND CERTIFICATIONS
  - AMBIENT CONDITIONS OR ALTERNATIVE (INSOLATION, TEMPERATURE, SHADING, ETC.)
  - DATA EVALUATION, PERMISSIBLE EXTRAPOLATIONS, AND INTERPOLATIONS
  - MANPOWER AND ACCEPTANCE AUTHORITY
- REVIEW AND MODIFICATIONS OF O&M MANUALS

FIGURE 2-5. TEST AND EVALUATION (T&E)

Work Monitoring--

The purpose of work monitoring is to alert management in a timely fashion to problems that can result in failure to complete a particular task, and to provide the opportunity to adjust staff assignments and work loads accordingly. At the same time, it identifies significant breakthroughs or critical weaknesses that can have an impact on the overall effort for Phase 2.

One of the most important methods of monitoring the project effort is through the reports of task accomplishments and potential problems provided by the task leaders to the project manager. A work environment is maintained in which task leaders and the project manager communicate significant happenings to each other on a daily basis. This reporting serves to identify potential problem areas in time to allow consideration of possible alternative courses of action.

The project uses three formal methods for monitoring task and subtask activities, with each method serving a separate, but mutually-related purpose.

- Weekly Project Report—The task leaders and other staff members meet regularly each week to report the status of individual tasks, to assess the overall project, and to identify problem areas. These meetings provide the opportunity for mutual exchange of essential data, coordination of tasking and interdependent efforts, and the identification of problem areas for discussion and resolution. The weekly report summarizes the status and deviation from the plan, and evaluates the impact of any deviations on the overall completion schedule.
- Monthly Project Report—The monthly report is the task leader's evaluation of the completion status of each task compared with the plan milestones and the allocated budget. If slippage has occurred or is anticipated, the task leaders must describe what is being done or what is needed to bring the task back on schedule. The monthly reports are inputs to project status reports to the client.
- Interim Task Review—Each task of two or more months' duration is subjected to interim task reviews at approximately the 30, 50, and 80 percent completion levels. This comprehensive review provides for the reallocation of resources if required to accelerate the effort for each task.

Schedule Control--

SAI uses the PERT/CPM and precedence networks as the basic control tools for the overall project. Our task force-oriented management approach is ideally suited for the effective utilization of such techniques to ensure successful completion of the project within the overall schedule. Each phase of the project will be controlled on a daily basis, and reviewed comprehensively every two weeks. The bi-weekly coordination meetings will be held by the Project Director and attended by the Project Manager, Project Engineer and key personnel in each technical/engineering discipline. The implementation or construction schedule is developed based on the specifications and drawings generated under Task 2. The Critical Path Method (CPM) will be used to evaluate the project and identify and correct potential problems. The detailed CPM will include all procurement, fabrication, and construction time tables.

The BAI PERT Project Management System, developed by BAI Incorporated, is used to assist the project manager in planning and managing the project. It is a computerized critical path, fast-tracking system, capable of integrating all phases of the project. These include planning, scheduling, estimating, monitoring, resource allocation, cost analysis, and performance control. It is operational on our Tektronix 4054 graphics computer and is used in an interactive mode. The program utilizes activity data such as description, code, dependencies, duration, and resource data either in the form of personnel or equipment such as type, percent commitment, rate, availability, etc. It provides a continuous and interactive system of tracking the project status from award to completion of contract. The information output is extensive and includes items like manpower and materials allocation, economic order quantity, lead time, budget deviations, schedule slippages, percent completion, progress and cumulative payments, retainage, change order, labor and other direct costs, etc. Careful evaluation is conducted at the 30, 50, and 80 percent completion points of the project to implement corrective actions if any are required. Project cost (installed) estimates are accomplished at these points and compared with the estimates provided at the start of the contract. These frequent estimates aid in defining the amount of engineering to be completed to assure the estimating accuracy required and the final installed cost.

Cost Control--

For cost control purposes, SAI employs a job-order cost accounting system that uses a 15-digit control field. Each contract or job is assigned an individual 11-digit number. All direct charges are coded to this number. Charge codes originate on source documents such as time sheets, purchase orders, and invoices. Each charge is assigned an additional 3-digit code to provide a general ledger control description; 1 digit is reserved for future needs.

The SAI internal management information service provides the following computer reports that will be directly useful and adequate for maintaining cost control:

- Management information Service 74--Detail of Direct Cost Biweekly
- Management Information Service 85--Monthly Budget Analysis.

The first of these reports is a computer printout of labor hours, the acquisition, delivery, and payment of materials and services, and other direct costs charged against the contract or job. It is a detailed accounting of charges on a biweekly basis. The second report is a monthly summary of charges against the contract or job, with a presentation of actual charges against projections entered by the contract administrator.

The project expenditures from the task plans will be entered into the system for use as planned expenditures for the monthly budget analysis reports. The biweekly labor hours reports will be used to make checks against task plans. Use of these two reports will allow the project management staff to monitor the expenditure of contract resources closely and to maintain tight cost control.

A log is maintained of daily commitments of non-labor contract costs and reconciled on a bi-weekly basis against the computerized Project Cost Report. This ensures the timely allocation of funds and maintains close control of all expenditures. Any unexplained variances are brought to the attention of the Project Director.

Configuration Control--

Configuration Control or Engineering Change Control refers to the specific procedures by which any changes to drawings are proposed, approved, recorded, and distributed. Changes are always expected, especially in a facility to be used for R&D purposes. Configuration control begins at the point where drawings are released for production. These procedures are highly formalized and comprehensive. It ends when the system has passed the acceptance tests. Typically all information under configuration control must be approved by Engineering. Configuration control consists of the following elements:

- Notification of Pending Change. Change may be requested by:
  - Owner (MRI)
  - Team Member
  - Subcontractors
  - Regulating Agencies
- Evaluation of Change on Cost and Schedule
- Contractual Implications of Change.

Spare Parts Inventory Control--

The R&D nature of the project and its location with respect to equipment suppliers requires a spare parts inventory to minimize extended down times. Appropriate controls over the spare parts must be maintained to minimize cost.

Quality Control--

Three major areas are included in the quality control function:

- Quality control of materials and equipment purchased or supplied by SAI and the subcontractors
- Quality control of the workmanship and procedures involved in the fabrication and installation of the system
- Quality assurance through testing, alignment, and functional checkout of subsystems and the completed system.

The basis for quality control is the qualitative and quantitative data incorporated with the purchase orders, component specifications, contracts, and drawings. Prior to the release of any of the foregoing items, a checklist will be used to ensure that functions, materials, dimensions, tolerances, finishes, and applicable standards are fully defined and that provision is made for inspection and verification of compliance. SAI will emphasize quality assurance and quality control (QA/QC) to ensure a successfully operating system and to provide the government technical representative (GTR) ample opportunities to assure quality at all times. This emphasis by SAI on QA/QC is required due to the experimental nature of the project. In general, QA/QC involves several steps, namely, sources inspection, in-process inspection, testing and final in-plant inspection, shipping and receiving inspections, and installation and checkout inspections prior to final checkout and acceptance. However, not all of these inspections are required for every component of the system and for every work element of the installation. For example, in the case of the standard commercial items, compliance with manufacturer's product specifications and industrial specifications and standards (ASTM, NEMA, Mil Specs) is appropriate. For the developmental components, such as the PV modules, all inspection steps should be applied. The QA/QC activity considered relevant to different aspects of the proposed system are discussed below. A draft of a Quality Assurance Manual to be used in the performance of work under Phase II has been prepared.

Materials and Equipment -- The quality control procedures for materials and equipment will vary with the value and the functional significance of the items involved.

In the case of purchased standard equipment for which the manufacturer's specifications and data sheets are sufficient, the equipment will be inspected upon receipt for quantity, condition, and conformance of the nameplate data with that contained in the purchase order or contract. Purchase orders and contracts will require that the vendor certify on the invoice that the items supplied conform to the manufacturer's specifications.

Specifications for standard materials, such as structural steel, conduit, and cable will be based upon standard industrial specifications. The purchase order will require certification of compliance on the invoice. All such materials shall be inspected upon receipt for quantity, size, finish, and condition.

Special equipment or modified items of standard equipment will be covered by detailed specifications. Each such item shall be inspected for material, workmanship, compliance with the specifications, and adequacy of manuals or documentation. Functional testing will be conducted, either/or both at the vendor's plant and at the receiving site, depending on the nature and value of the equipment.

Major developmental or custom items will be subjected to detailed quality control procedures; the extent will depend on its functional significance, value, the state-of-development, and the appropriate specifications.

Site Fabrication and Installation -- The principal agents for quality control on site will be the general contractor and the on-site project representative. Fabrication and installation activity will undergo continuous inspection. Checklists covering each item in the specifications will be issued to ensure compliance with the specifications. In addition, SAI will provide on-site inspection during each phase of construction. Standard construction practice for payment will apply. The general contractor must complete each phase of the site work and have it approved prior to payment.

Test and Checkout -- Incremental testing will be performed where possible to facilitate the final system check.

For example, all power system sensors and instruments will undergo factory test and calibration. After installation, a continuity check will be made on the conductors between the sensors and the interface/instrument cabinet. During the initial system operation period, instrumentation outputs will be compared against those measured with precision portable test instruments.

Safety systems will be checked out and compliance with NEC National Fire Code, and local building codes will be certified. Testing required by these various codes (e.g., hypotting, ground resistance) will be performed prior to system operation. Performance verification will include the evaluation of system response to alternative loads and intentionally induced transients. A final performance and acceptance test will be conducted by the contracting officer's representative (COR) and SAI.

Task 2 - Engineering and Design

The emphasis of this task is to refine the preliminary design of Phase 1 to a) achieve simplicity, lowest practical cost, reliability, and deployability commensurate with the chosen site and the overall specifications and guidelines specified in the Contract, b) develop all production drawings necessary for the procurement, construction, installation and checkout, and c) develop the necessary manuals and procedures for checkout, operation, and maintenance.

This task also encompasses the verification analyses required for equipment to be designed and constructed by other firms under contract in order to assure a quality product. The effort required under this task can be summarized as follows:

1. Verify preliminary design calculations
  - Inputs, outputs, temperatures, pressures, flowrates, volumes
  - Equipment sizes, lengths, diameters, thicknesses, weights
  - Controllable functions, sensor data needed for decisions
  - Update force, mass and energy balances.
2. Analyze installation, operation, and maintenance requirements
  - Tractable assembly and subassembly sizes
  - Lifting eyes, protection of fragile appendages
  - Access points, isolation valves, switches, etc. for maintenance
  - Sensors for maintenance, safety
  - Ladders, platforms, lighting, utility services.
3. Prepare detailed drawings
  - Dimensions, materials, fittings, finishes
  - Correlate physical and electrical details with adjoining subsystems components, and parts

- Outline and interface drawings for correlation with general arrangement, site plans, and foundation plans.
- 4. Prepare detailed specifications
- 5. Develop installation, operation, and maintenance procedures/plans.
- 6. Tabulate quantified utility requirements.
  - Air, water, steam, electrical - volumes rates, temperatures, pressure, voltage, current duty cycles, etc.

Under the Engineering and Design task the computer program developed under Phase I for simulating the performance of the system will be refined and expanded to reflect the engineering field test facility as built. It will be used during acceptance testing, the verification of system operation, and the evaluation of test data. The following activities are also the responsibility of Engineering.

Field Engineering Observation and Certification--

To ensure proper implementation of specifications and drawings, site visits are made by appropriate engineering personnel to observe and certify the procedures for the major systems. Cognizant personnel for these activities will be designated by the Project Director.

Change Order Analysis--

Engineering is responsible for evaluating the merits of proposed changes. Changes may be required to drawings and/or specifications and may involve new analyses and equipment or system reconfiguration.

As Built Drawings--

After completion of construction and passing of acceptance testing, engineering must approve all as built drawings. This requires a reconciliation of all change orders. Installation procedures and/or manuals must be updated to reflect actual experiences.

Task 3 - Procurement/Fabrication

The Procurement/Fabrication task takes the output of the Engineering and Design Task, which is in the form of detailed specifications and drawings, develops an implementation schedule, and solicits quotations, evaluates them and places the orders for the chosen subsystems, assemblies, components, and parts. The basic procurement process can be summarized as follows:

1. Categorize subsystems, assemblies, components and parts into homogeneous (from a manufacturing or supply viewpoint) elements
2. Identify potential vendors
  - telephone contact to obtain expressions of interest.
3. Solicit quotations
  - to drawings and specifications
  - lead time
  - duration of validity
  - total cost (cost, insurance and freight)
  - applicable taxes
  - value engineering clause
  - legal and institutional provisions.
  - warranties
4. Evaluate quotations
  - value engineering, impact on other elements
  - delivery time
  - cost, at site
  - for critical items, assess ability to delivery, reputation of supplier.
5. Prepare subcontracts and purchase orders
  - progress payment provisions
  - inspections and certifications.

6. Inspection and acceptance

- vendor liaison and progress reviews
- witnessing of tests (or certifications)
- verification of compliance - tools, instruments required.

For the major items a procurement plan will be developed for each item and agreed upon with the proposed supplier. This plan will include a description of the item or items, the technical specifications, fabrication and delivery schedules, and quality assurance provisions.

It is the goal of SAI and its subcontractors to purchase the required materials, supplies, and services based on evaluations of price, delivery, and quality consistent with the lowest ultimate cost.

To obtain this goal, it is our plan to follow the formal policies and procedures established and published in Corporate Purchasing Instruction and monitored for compliance on an on-going basis by SAI Internal Audit and DCAS.

It is SAI's policy to place purchase orders only with those suppliers who have proven their reliability and capability. All purchases at SAI shall take advantage of competitive market forces to the maximum practical extent, consistent with technical requirements. Objective evidence supporting the supplier's previous record of supplying high quality articles of the type being procured is reviewed prior to their being approved. Each approved supplier's performance will be summarized on a monthly and quarterly basis, the data are reviewed by quality and purchasing management on a regular basis. New sources of supply are constantly being developed to avoid sole source procurement and to foster competitive bidding.

We will select the source(s) for the major subcontracted items based on the evaluation of potential suppliers by a team consisting of representatives cognizant in the areas of Purchasing, Engineering, Manufacturing, Quality Assurance, and Finance. The team will establish weighted point totals for each potential supplier based on the following criteria:

1. Technical design.
2. Facility survey-equipment, capacity, labor relations.
3. Vendor quality and reliability survey.
4. Vendor committed delivery schedule and our confidence in meeting it.
5. Vendor price and substantiation - including freight cost.
6. Fabrication site location.
7. Amount of subcontracting to be done.
8. Vendor management - includes financial condition, previous experience with similar product, and experience with Federal regulations.
9. Maintainability and warranty of the item supplied.

The Procurement buyer(s) are accountable for all aspects of the procurement, including delivery performance.

The quality levels for the program will be developed to establish appropriate quality and certification criteria based on contractual requirements. These requirements become part of the purchase order specification package.

Task 4 - Construction/Installation

Under this task all equipment received at the site will be uncrated, checked for damage, installed, assembled or constructed, and checked out for operation. The plans developed under the Engineering and Design tasks will be executed to ensure proper installation and system performance.

Task 5 - Operation and Maintenance

The principal activities to be carried out under this task during Phase 2 is to prepare the necessary plans and manuals for the operation and maintenance of the ETF during Phase 3. In addition, all necessary training of operators and maintenance personnel required in Phase 3 will be organized and conducted under this task.

The specific plans and manuals will be prepared after specific equipments have been selected. The O&M manuals will be divided into an overall Facilities manual and a variety of subsystem manuals. Figures 2-6 and 2-7 provide tentative outlines of these two types of manuals.

Part of the operation function is the conducting of tests to verify and evaluate system performance characteristics. Testing has been discussed in the Task 4 report with respect to ensuring an operational system according to the specifications. The test plans to be addressed here deal with the gathering of data and information that would be useful in the design of commercial systems. Such data are to be useful for the prediction of system performance and should therefore be tied in closely with the analytical models used to simulate system behaviour under a wide variety of operating strategies. The information obtained from tests prior to regular system operation is an important input into the ability to forecast or evaluate long term behaviour. Tests conducted during the implementation phase consist of basically the following types:

- Testing at the Manufacturer/Fabricator
- Installed Equipment Tests
- Calibration and Startup Tests
- Acceptance Tests
- Performance tests

These tests represent a sequential quality assurance check to verify that the equipment will perform as designed. The last category of tests is only applicable to the engineering test facility while the other three are required for both the commercial and test facilities.

Testing at the Manufacturer/Fabricator--

These tests apply to equipment or components that have a limited history of performance in the field or that need be characterized accurately for experimental purposes. To ensure a quality product designed according to the specifications the procurement of that item may require a test report that shows compliance with the specifications. The tests may be performed at the facilities of the

Figure 2-6. O&M Manual Outline

Operation:

- Safety precautions
- System description
- Operational sequence for start-up, sustained operation and shutdown for each level of operation
  - specific steps to be taken for each sequence
- Automated operation
- Manual (Fall-back Mode)
- Processor, display and I/O description
  - functional description
  - software module from charts

Maintenance:

- Safety precautions
- Preventive maintenance
  - schedule of tests, inspections, adjustments, routine replacement, etc.
  - preventive maintenance logs
- Corrective maintenance
  - trouble shooting diagrams and sequences for each subsystem
  - specific corrective actions for common faults
  - reference list for all test facility documentation covering repair and adjustments

Resources (Excluding personnel):

- Special tools and equipment.
  - items not included in the test facility design, but required for O&M. Includes truck(s), forklifts, crane?, roof servicing skid, welding equipment, machine shop, chemistry laboratory equipment, etc.
- Material
  - consumable supplies - stock limit, low limit, perishability, consumption rate, etc., includes chemicals, lubricants, etc.
  - replacement parts, discrete identification of major items, planning factors for minor items. Spare parts list.
- Services
  - maintenance contracts for specialized services or peripherals
  - RO system solar collectors

Skill and Craft Levels:

- Identification of functions to be performed - translate into craft levels
- Job descriptions

Figure 2-7. Subsystem O&M Manual Outline

- Description (Overall System)
- Theory of Operation
- Specifications, Tolerances, Limits
- Parts Identification and Description
- Preventive Maintenance Instructions
- Trouble Shooting Instructions
- Corrective Maintenance Procedures
- Warranty Provisions

manufacturer/fabricator, or may be conducted at an independent laboratory, and may be witnessed by a representative of the buyer.

For an experimental facility more tests may be specified than would ordinarily be the case for a commercial facility. For example, a test report will be requested for each of the well pumps to be installed at the ETF so that the exact characteristics are known. These would be required in order to evaluate the performance of the overall systems with a reasonable degree of accuracy. For a commercial facility the typical performance curves of such pumps would be sufficient to allow the sizing of the various subsystems. Specific test reports will be requested for the following items:

• Tefzel	• All major pumps
• Greenhouse glass	• Fan coil unit
• Soil	• All test instrumentation
• PV modules	• RO Membranes
• Electric storage batteries	• CO ₂ generator
• Power conditioning unit	

These test reports would generally include the information listed in Figure 2-8.

Figure 2-8. Preliminary Outline of Test Report

Installed Equipment Tests--

Equipment received from the manufacturer or fabricator at the site of installation must be checked to ensure that:

- No damage occurred during shipping, uncrating, and handling at the site;
- The unit has been installed properly according to approved drawings, specifications, codes, and standards.

Such tests are generally comprised of visual checks; motion checks such as rotation or deflection; and continuity checks for detection of plugged units, short or open circuits, etc. Such tests are generally conducted with a checklist to be followed. These tests are generally done by the construction contractor which then releases the equipment for calibration, testing, and operation. Data sheets, test records, and other required documentation are filled out, and the system "as built" drawings are made.

Calibration and Startup Tests--

The Calibration and Startup Tests ensure that the equipment and systems are ready for release to the owner for the acceptance tests. Many of the tests and procedures required to accomplish this objective for the ETF fall in this category. Additional tests or procedures may be required as dictated by the final design of the ETF and its functional integration with the other subsystems. All of the procedures described are conventional in nature and are commonly used in the startup of relatively complex systems. The majority of these activities are the construction contractor's responsibility. Results from these tests will be collated and made part of the system data base. These tests include pressure tests, vibration tests, water quality tests, electric circuit breaker tests, relay tests, etc., and calibration tests on all instrumentation.

Acceptance Tests--

These are the most important tests and they should show that the integration of subsystems was accomplished as per specifications. Such tests last for days, weeks, and may be months depending on the complexity of the system. Although

administratively and technically distinct from the engineering and construction phase of the project, acceptance testing overlaps the construction schedule, and extensive coordination is required to effect smooth turnovers of equipment and ready the facility for operation within schedule and budget. The acceptance test data are important from the standpoint of verification of the modeling techniques. They also provide useful information about system startup functions and procedures that can be extrapolated to commercial sized systems.

Performance Tests/Data Acquisition--

The tests discussed above all deal with ensuring that the system and hardware is designed according to the specifications. Performance tests are additional tests to be conducted after the system has been put in operation and are designed to provide information about system response to extreme conditions, equipment and material durability, long term degradation effects, suitability for operation and maintenance, cost effectiveness, and the assessment of the validity of the theoretical models that were used to design the system initially. The latter objective is particularly important since the cost effectiveness of the system is based on the ability to predict greenhouse performance and crop yield. The ETF has been designed with a significant number of instruments that collect data on subsystem performance. The information collected by the data acquisition system has been detailed in the Task 4 report and will be used to assess the validity of the model. Specific performance test are needed to supplement this data to gather insight in certain uncontrollable variables. The performance tests have therefore broad objectives and are linked with the day-to-day data acquisition process. The specific objectives can be classified into two categories namely those dealing with the environment created by the structure and the equipment, and those dealing with the horticultural functions. Both, however, are linked together via the SG78 computer program that was used in the project to determine the roof cooling, air dehumidification, and CO₂ enrichment requirements. The validation of this computer program therefore represents a major aspect of the data analyses process during Phase 3. The general objectives can be summarized as follows:

Greenhouse Environment -- The first set of objectives deals with the long term operation assessment of the greenhouse system according to the design specifications. Specifically the following points need to be addressed:

- a. the ability to use the indirectly determined leaf or plant temperature to control the roof cooling and dehumidification systems;
- b. the ability to control CO₂ levels in the greenhouse and to determine the relationship between CO₂ injection and amount of CO₂ fixed in the plants as a function of the meteorological parameters;
- c. the ability of the systems to control relative humidity and temperature within the control bands specified;
- d. the ability of the systems to provide the required amounts of water for crop irrigation, and recover condensate from the dehumidification system for reuse;
- e. the ability of the greenhouse enclosure to maintain its radiative properties, such as transmission, reflection, and absorption, over its lifetime as impacted by material degradation by UV and dust accumulation from storms and rain;
- f. the ability of the PV system and electric storage batteries to provide power to maintain essential system functions operational during abnormal conditions;
- g. the ability of the PV system and electric storage to satisfy the normal power requirements;
- h. the ability of the roof cooling system to maintain roof temperatures within the acceptable limits during summer and winter time conditions.

Horticulture Environment - This second set of objectives deals principally with the evaluation of the amount of crop enhancement made possible by the system design. Specifically, the following points need to be addressed:

- a. the ability to be able to determine the amount of water needed for the various crops;
- b. the ability to be able to determine an average leaf temperature for use in the system control algorithm;
- c. the ability to be able to control plant disease with the roof cooling and air dehumidification systems;
- d. the ability to maintain an adequate human working environment;

- e. the ability to measure increased produce yield or plant growth as a function of CO₂ enhancement during the various growth stages.

To support the attainment of these objectives specific tests must be performed in addition to the information gathered on a regular basis by the data acquisition system. The tests presently contemplated are listed below and will be developed in more detail during Phase 2.

Compartment Envelope Integrity -- Tests similar to those used in the acceptance testing process will be conducted periodically during the operational period of the ETF. These are done to evaluate any loss of integrity that may be caused by natural forces, such as high winds, thunderstorms, etc., or earth and foundation settlement. Increased infiltration resulting from loss of envelope integrity will result in increased consumption of power, water, and CO₂.

Infiltration Characterization -- It is virtually impossible, nor is it desirable, to make the greenhouse absolutely airtight. Air leakage paths exist almost everywhere, however, and must be minimized. Increased air infiltration results in increased consumption of power, water and CO₂. Air infiltration is desired to minimize the accumulation of harmful gases to man and plant. Infiltration is a strong function of wind speed and wind direction and cannot be characterized analytically. It is a significant factor in being able to assess greenhouse performance. Tests to characterize air infiltration as a function of wind speed and direction will be conducted at a suitable time. It is presently estimated that sufficient information can be gathered by testing one compartment void of plants over a period of several days.

Tefzel Degradation -- Manufacturers data show that no deterioration of the film cover is expected over the operation period of the greenhouse. The material specifications are based on clear and uncontaminated materials, as the effects of dust and dust accumulation must be evaluated. Periodically, the transmissivity of the greenhouse cover, Tefzel and glass, will be measured as a function of wavelength at several locations in the greenhouse.

Roof Cooling Effectiveness -- To determine the effectiveness of the roof cooling system the effect of water flowrate needs to be evaluated. Clear sunny days with empty compartments will provide the test results. The experiments are to be

carried out around solar noon. Compartment temperature and humidity and outside conditions are to be monitored continuously while maintaining the roofwater flow rate at a constant value. These tests are to be repeated for several flowrate settings, including no flow.

Reheater Performance -- Including the reheater in the dehumidification loop provides for better control of the relative humidity in the greenhouse. There is some question whether the gain in humidity control and lower power requirements is offset by the cost of piping required to operate it. Operating two side-by-side compartments with approximately the same crops, one with and the other without the reheat system on, for several days under the same control strategy would provide information about the usefulness of the reheat coils.

PV Array Performance -- PV array performance must be evaluated on a periodic basis to assess the effects of dirt and dust accumulation as a function of insolation, ambient air temperature, and windspeed.

RO Membrane Flux -- The membrane productivity (flux) characteristics change as a function of time, pressure and water temperature. Manufacturers ratings are typically for a stable membrane at a given temperature and pressure. Temperature correction curves are sometimes provided. Periodic tests should be conducted over the range of RO operating conditions to characterize its performance.

CO₂ Distribution -- CO₂ is distributed in the greenhouse at specific locations. The rate at which CO₂ diffuses throughout the greenhouse and plant foliage is unknown and is affected by resistances in the greenhouse and air infiltration. Tests will be planned to measure CO₂ concentrations at several points in the ETF and at several growth stages of the plants. Testing is contemplated during early morning hours and late evening hours when the CO₂ supply is turned on and turned off, respectively.

Passive Ventilation -- The amount of passive ventilation (louvres open and fans off) that can be obtained with the present configuration is unknown. This should be measured as a function of windspeed and direction and plant size, since the latter provides a resistance to air flow. These tests could be extended to include active ventilation as a function of the same parameters.

Environmental Variability -- To determine the effects of factors that could cause variations in the crop in the greenhouse a quick crop (i.e., radish, lettuce, summer squash, spinach, or snap bush bean) is planted throughout all four greenhouse sections. The crop will be used as a "bioassay" to determine the effects of interior and exterior walls, CO₂ distribution, water drainage, compartment orientation, control set points for temperature and humidity, and simulated system malfunctions. Both summer and winter conditions need to be evaluated. These tests would probably take place during the first year of operation.

Crop Production Potential -- The second year would be devoted to the evaluation of the effectiveness of CO₂ enrichment on a constant mix of crops during different times of the year. From two to four crop species will be selected (i.e., tomatoes, cucumber, green beans, radish) using a selection of different varieties within each of the species will be grown in one or more compartments and rotated to simulate potential commercial practices.

Daily Monitoring -- There are a variety of observations to be made during the operation of the greenhouse that do not lend themselves to controlled test procedures or instrument recordings. During Phase 2 a list and a set of procedures will be prepared that require recording of visual observations in a logbook. Such items include, but are not necessarily limited to, the following:

- equipment outages (controlled and uncontrolled)
- condensation patterns on walls, roofs and Tefzel
- dust/dirt accumulation patterns on greenhouse and pv array
- shadow patterns
- response of system during high winds and severe rain storms
- operation personnel reactions to working conditions
- fertigation practices (frequency, flow/delivery rate, nutrient concentration, nutrient composition)
- crop productivity at various stages
- disease control

- leachate control
- cleaning operations for roof and PV array
- environmental impacts.

Staff Requirements--

The minimum staffing and personnel qualifications required to operate the Engineering Test Facility have been described in the Task 4 report. To achieve a successful startup, conventional power plant experience has demonstrated the value of placing a key member of the operation staff on the project team early in the final design and construction phase. It is suggested that this person be the General Manager of the ETF during Phase 3. He will review engineering drawings and contribute to the project design by providing input on startup operations and maintenance. He must also make sure that adequate provisions are engineered into the permanent plant systems to accommodate temporary facilities required for startup. He would also supervise the preparation of contracts and manuals for startup, including administrative and technical procedures and startup testing procedures. He would prepare a time startup schedule in coordination with the status of the actual construction of the ETF and the planned operating schedule.

In order to ensure smooth operation of the ETF during Phase 3 it is important to train key personnel prior to the initiation of the operation phase. It is highly beneficial to engage, in addition to the already present General Manager, the Engineer and the Horticulturist during Phase 2. They will be brought on board at the time when the system is made ready for acceptance testing. Equipment operation will be done by these three people. This break in period is expected to last no more than two months. Training to take place during this time frame would consist of both the theoretical areas and hands-on experience.

THE WORK BREAK DOWN STRUCTURE

The WBS is detailed in Table 2-1. It follows the five tasks identified in Figure 2-1.

Table 2-1. Work Breakdown Structure (WBS)

<u>WBS No.</u>	<u>WBS Element Description</u>
1000	PROJECT MANAGEMENT
1010	Work Monitoring
1020	Cost Control
1030	Schedule Control
1040	Subcontracts Administration
1050	Reports and Meetings
1060	Quality Assurance/Control
1070	Configuration Control
1080	Spare Parts Inventory Control
2000	ENGINEERING AND DESIGN
2010	Greenhouse Envelope - Foundations - Support Columns - Trusses - Glass Roof - Plastic Film Cover
2020	Space Conditioning Systems - Air Handlers - Heat Exchangers - Ventilation Fans - Pumps - Valves - Piping
2030	Planting, Growing and Harvesting Equipment

2040	Photovoltaics Subsystem
	- Review Phase 1 - Module - Field Layout - Electrical Design - Support Structure - Foundation - Collector Cleaning System - Mathematical Modeling
2050	Site Development
	- Site Use Permits - Soil Test Borings and Analyses - General Arrangement - Environmental Assessment - Utilities Planning - Site Grading
2060	Meteorological Station
	- Definition of Data Requirements - Definition of Interfaces - Station Specifications
2070	Support Building
	- Floor Plans - Equipment Arrangement - Electrical Systems - Mechanical Systems - Foundation - Structural Design - Greenhouse Link Corridor - Loading Dock
2080	Control and Data Acquisition Subsystem
	- Review Phase 1 - System Control Algorithms - Instrumentation Specifications - Software Requirement Definition - Computer and Console Definition - Control System Specifications - Mathematical Modeling - Review of Test Plans - Instrumentation Requirements Definition - Data Analysis Requirements Definition - Specification of Data Acquisition System

2090	Electrical Storage System
	- Review of Phase 1 - Battery Module - Battery Layout - Electrical Design - Support Structure - Foundation - Safety Systems - Mathematical Modeling
2100	Desalination/Water Purification System
	- Pretreatment - Reverse Osmosis - Demineralizer
2110	Produce Storage Facilities
2120	Electrical Distribution Subsystem
	- Power Requirements Definition - Feeder Panels and Switchboards - Power Conditioning Unit - Utility Interface - Mathematical Modeling
2130	Crop Residue Storage and Disposal Facility
2140	CO ₂ Generator/Storage Ssystem
2150	Ground Water Wells/Pumps
2160	Miscellaneous Facility Equipment
	- Service Vehicles - Maintenance Tools
2200	Field Engineering Observation and Certification
2300	Change Order Analysis
2400	As Built Drawings
2500	Test Plan Development
3000	PROCUREMENT AND FABRICATION
3010	Greenhouse Envelope
	- Structural Steel - Glass - Tefzel

3020	Space Conditioning Subsystem
3030	Planting, Growing, and Harvesting Operations
3040	Photovoltaics Subsystems - Modules - Support Structure - Cabling, Diodes, etc. - Collector Cleaning Equipment
3050	Meteorological Station
3060	On-site Development - Grading - Access Road - Temporary Facilities - Foundations for Greenhouse - Foundations for Auxiliary Facility Structures - Foundation for Meteorological Tower - Fencing and Paving
3070	Support Building
3080	Control and Data Acquisition
3090	Electric Storage Subsystem - Batteries - Support Structure - Cabling, Connectors, etc. - Safety Systems
3100	Desalination/Water Purification Subsystem
3110	Produce Storage Facility
3120	Electric Distribution Subsystem
3130	CO ₂ Generator/Storage Tank
3140	Ground Water Wells/Pumps
3150	Crop Residue, Storage, and Disposal Facilities
3160	Miscellaneous Facility Equipment
3200	Testing

4000	CONSTRUCTION AND INSTALLATION
4010	Site Preparation
4020	Greenhouse Envelope
4030	Space Conditioning System
4040	Photovoltaic Systems
4050	Meteorological Station
4060	Support Building
4070	Central Control System
4080	Desalination/Water Purification System
4090	Produce Storage Facilities
4100	Electric Distribution Subsystem
4110	Crop Residue Storage and Disposal Facility
4120	CO ₂ Generator/Storage Tank
4130	Ground Water Wells/Pumps
4140	Miscellaneous Facility Equipment
4200	Acceptance Testing
5000	OPERATION AND MAINTENANCE
5010	Training
5020	O&M Plans and Manuals

SECTION 3

PROJECT ORGANIZATION AND SCHEDULE

PROJECT ORGANIZATION

The project management and organization are required to achieve effective integration of multiple tasks and subtasks to ensure a coherent operating schedule, successful completion within the budget, and continuity of personnel and assignments for total execution of the next phases of the project.

The inherent nature of the project involving a variety of systems and functions, e.g., agriculture; solar energy; water desalination; system installation, integration, monitoring, and maintenance; support facilities and structure; etc., requires interdisciplinary capabilities in personnel and facilities. In view of these requirements, and to provide continuity into the next Phase, key personnel and organizations responsible for the successful completion of Phase 1 should be preferably engaged in Phase 2. It is also important that the prime contractor organization from Phase 1 be clearly responsible for the overall implementation and management of the project. The prime contractor and all its team members should have an established fiscal responsibility exhibited in the implementation of related and similar projects. In view of the above, the key subcontractor team members and their broad responsibilities in the projects are the same as those under Phase 1 and are given below. The team organization in relation to SAI is shown in Figure 3-1.

- Texas A&M University Agricultural Experiment Station (TAES) at Dallas will perform all work related to agricultural subsystems.
- Geiger Berger and Associates (GBA) will be responsible for the detailed design of the structures and enclosures including the support facilities and general site arrangement.
- Robert E. McKee, Inc., a well-known local construction firm, will be responsible for site development, value engineering, general construction contractor services, and field construction.

FIGURE 3-1. PROJECT TEAM ORGANIZATIONAL CHART

SUBSYSTEM	RESPONSIBILITY/ROLE*				
	SCIENCE APPLICATIONS, INC.	TEXAS A&M	GEIGER-BERGER**	McKEE	McCORMACK
AGRICULTURE	▲	●			
SOLAR ENERGY COLLECTION CONVERSION, STORAGE, & DELIVERY	●				
DESALINATION	▲				●
WATER STORAGE/ DELIVERY	●				
ENVIRONMENTAL ASSESSMENT	●				
WASTE RECOVERY/DISPOSAL	●			▲	
CONTROLS/INSTRUMENTATION	●	▲			
FOUNDATIONS, STRUCTURES, ENCLOSURES/FACILITIES } DESIGN	▲		●	▲	
DATA ACQUISITION	●	▲			
CONSTRUCTION	▲		▲	●	
*LEGEND — ● = PRINCIPAL RESPONSIBILITY ▲ = MAJOR SUPPORT RESPONSIBILITY **SMALL BUSINESS NOTE — FOR DETAILED LEVEL OF EFFORT, LABOR CATEGORY, SUBTASK LEADERSHIP AND OTHER RELEVANT DATA, SEE SUMMARY IN SECTION 1.					

FIGURE 3-2. BROAD TEAM MEMBER FUNCTION MATRIX-BY SUBSYSTEMS

- McCormack Corporation, a well-known firm in the area of desalination, ultrapure water systems and control instrumentation will provide the skid mounted RO and demineralizer systems.

Figure 3-2 provides, in a broad sense, a summary of team member responsibilities and role by major subsystems. These role assignments are based on the extensive, specific, and unique expertise of the participants.

PROJECT FUNCTIONAL ASSIGNMENTS AND ROLES

All work, to the conclusion of the project, should be directed by the Project Director. He shall be responsible for management control over all phases of the project effort, meeting all contractual obligations, coordinating activities for scheduling, cost/performance control, and estimating and maintaining liaison with the client's project representatives. His authority and responsibility shall encompass all basic policy decisions in accordance with the project requirements in order to ensure accomplishment of all areas of work within the time schedule and budget allocations. He shall be responsible for the administrative direction of all work on the project to ascertain that it is accomplished in a technically sound and cost-effective manner. The Project Director will have direct, continuing responsibility to SAI Corporate Management for meeting the total project requirements.

Coordination of all Phase 2 activities shall be performed by the SAI Project Manager/Engineer. His principal duties shall include reviewing the technical quality of engineering, design and construction, coordinating all interrelated efforts of the various disciplines, ensuring compliance to set schedules and budget allocations, and day-to-day administering and scheduling of personnel.

Reporting to the project manager/engineer will be lead engineers in each of the principal engineering disciplines, as shown in Figure 3-3. These individuals shall provide the primary link between project management and the actual working level of the project, and are directly responsible for the work completed by their design teams. They should present proven experience and success on similar programs.

FIGURE 3-3 PROJECT FUNCTIONAL ORGANIZATION

Construction management and field construction activities shall start in compliance with the project schedule when the effective date for commencement of Phase 2 is established. SAI and its construction subcontractor will be the key parties involved in this part of the work. The latter will provide general contractor support and field construction functions. Following the field construction go-ahead, the key field staff shall be assigned to the job-site and start establishing facilities for receiving equipment and material, as well as for personnel. Detailed procedures for receiving, inspection, and warehousing shall be defined to ensure compliance of all items received with specifications, standards, and drawings. The construction superintendent shall hold regularly scheduled meetings with construction supervisors, key field staff members, and construction subcontractors to review the overall process, future work schedules, and potential problem areas requiring early corrective action. Throughout the construction phase, the construction superintendent shall submit a bi-weekly report to the Project Director containing a comprehensive account of the project status and progress during the past two weeks.

SAI's procurement group shall support the project purchasing coordinator and expeditor in all procurement activities, from issuing the engineering requisition to the delivery of the item to the site. Procedures for flow of information and procurement/expediting status reporting shall be defined to mitigate delays in these operations. For the Phase 2 of the proposed project, the procurement of all high technology components/subsystems shall be accomplished by SAI while all items involved in general construction at the site will be procured by the general contractor/subcontractors.

PROJECT SCHEDULE

The project schedule is shown in Figure 3-4 with a list of documentation to be produced during Phase 2 shown in Table 3-1.

LEGEND:

— DOCUMENTATION REQUIRED AS PER ITEM X. SEE TABLE 3-1

CDR — CRITICAL DESIGN REVIEW

FIGURE 3-4. PHASE 2 SCHEDULE

Table 3-1. Documentation For Phase 2

<u>Item No.</u>	<u>Title or Descriptive Information</u>
1	Engineering and Manufacturing Documentation
2	Monthly Status Report
3	Test Plan
4	Testing - Documentation
5	Organization and Management Plan
6	Subcontract Management and Procurement Plan
7	Quality Assurance/Quality Control Plan
8	Inspection and Checkout Plan
9	Manufacturing Flow Plan
10	Acceptance Test Plan
11	Operation, Maintenance and Training Plan
12	Final Report

APPENDIX A

COST ESTIMATE AND SCHEDULE FOR CONSTRUCTION IN SAUDI ARABIA

The cost of constructing an Engineering Test Facility in the Kingdom of Saudi Arabia (KSA) must consider two factors. First, the environmental control systems, portable water production systems, and energy systems must be adapted to the specific site in the KSA, and second, the basic costs of construction are different in the KSA as compared to the US. The requirement for adaptation to KSA sites and system cost sensitivities resulting from such changes are described in the Task 3 report. These cost sensitivities are based on the construction of such a facility in the US.

The principal reasons for the cost differential are due to the limited availabilities of materials required for construction and skilled technicians and engineers. Much of this has to be imported. In addition to the added costs of construction an increase in transportation and handling costs will be incurred due to the necessity of shipping high-technology items from the US to Saudi Arabia. These include the photovoltaic panels, the batteries, power conditioning unit, control system, meteorological station, the reverse osmosis desalination system, the special greenhouse glass roof panels, and the Tefzel film cover material and the like. The two principal site specific items that could impact the cost delta for Saudi Arabia are the depth of the well and temperature of the groundwater. The effects of these items, as they impact the construction of the SCEAS in Saudi Arabia, are discussed in the following paragraphs. The change in costs between the KSA and US are presented in terms of a percent change to the total system costs. As a result, the contribution of various equipments to the total system cost is different for the commercial facility than it is for the Engineering Test Facility. This is due to the cost assumptions made for the commercial facility, where "cost goals" data was used rather than actual cost as has been discussed in the Task 3 report.

Construction Costs and Schedule. Experience with construction projects in the KSA has shown that the implementation of any given construction projects costs more in the KSA than in the US. However, construction schedules can often be shortened by 20 percent or so with the appropriate liability/incentive clauses in contracts with the construction firms. The firms doing business in the KSA normally

provide all conventional building materials. The same situation can be expected for the SCEAS project, except for those subsystems noted in the previous paragraph. The high-technology items to be procured in the US and shipped to the KSA represent a larger percentage of the capital cost (14 percent) for the Engineering Test Facility than they do for the commercial facility (ten percent). Thus, the cost adjustment for KSA will be somewhat different for the two types of facilities.

It is SAI's estimate that the overall schedule for Phase 2 will be approximately three months longer than that shown in Figure 3-4. This schedule extension is necessitated by the increased effort required for final design at the Riyadh site, increased shipping times and increased travel times for supervisory personnel.

Experience has shown that construction costs in KSA are very nearly 1.5 times as high than for the same project in the U.S.. Thus the cost multipliers for the two sizes, due solely to increased conventional construction costs, are:

Engineering Test Facility	$1.5 (1.0-0.14) = 1.29$
Commercial Plant	$1.5 (1.0-0.10) = 1.35$

Shipping Costs. Shipping costs to KSA vary with the size of the shipment. They also vary with the nature of the cargo. For cargo of high density the costs are driven by weight. For large, bulky cargo of low density the costs are driven by volume. The SCEAS items to be shipped are principally dense cargo items with costs driven by weight. As a result the shipping costs have been computed to add three percent to the cost of the commercial facility, but only one percent to that of the Engineering Test Facility.

Well Depth. It was stated in the Task 3 Report that the well depth near Riyadh was roughly ten meters, the same as that at El Paso. Subsequent information obtained from SERI has shown that these shallow wells are going dry in the vicinity of Riyadh at 80 meters. An 80-100 meter well depth appears necessary. Figure 5-4 from the Task 3 Report shows a ten percent system cost increase for a 50-meter well depth for the commercial system. Within this level of accuracy, a twenty percent cost increase can be anticipated for an 80-100 meter well depth. The effect of this on the pilot plant will be much greater, because the percentage cost of the systems affected by the increased power requirement (PV, battery, power conditioner) is higher for the

Engineering Test Facility than for the commercial facility. The percentage overall system cost increase due to the well depth is estimated at thirty percent for the Engineering Test Facility.

Ground Water Temperature. The ground water temperatures for the Riyadh site are 30°C, compared to 18°C at El Paso. Figure 5-5 of the Task 3 Report shows this as causing only a two percent increase in system cost. Since an evaporation pond must be installed, a three percent cost increase is estimated for the Engineering Test Facility.

Summary. Table A-1 summarizes the percent increases in system costs due to the above items for both the commercial facility and the Engineering Test Facility. To the level of accuracy of this analysis, the annual costs are increased by this same increment, so that these increments represent the same increase in produce costs as well as capital costs.

Use of Diesel Backup. An additional change in the Engineering Test Facility System for the Riyadh site involves the use of a diesel generator backup system rather than use of the utility. Such a backup system will allow for greater reliability as well as provide an inexpensive source of CO₂ by scrubbing the exhaust gases. No major change in cost is anticipated by utilizing diesel instead of utility backup.

Production of CO₂. It is important to find a low cost method to produce CO₂ for the greenhouse. Purchasing CO₂ could cost about \$1/kgm. SAI has investigated a variety of ways to produce CO₂ onsite. These include acid treatment of well water and burning of carbon based fuels in addition to those methods discussed in the Task 3 Report. All onsite methods appear to provide CO₂ at over \$1.10/kgm with the exception of burning of carbon based fuel which can give CO₂ at less than \$0.25/kgm and is therefore the preferred method.

One method not investigated which might have some promise is the bacterial decomposition of low cost heavy refinery by-products (for example asphalt). A research project would need to be initiated in order to determine the viability of this method.

Table A-1. Summary of Percentage Cost Increase for Saudi Arabia

	<u>Commercial Plant</u>	<u>Engineering Test Facility</u>
Construction Costs	35	29
Shipping Costs	3	1
Well Depth	20	30
Groundwater Temperature	<u>0</u>	<u>3</u>
Total Percent Increase	58	63

APPENDIX B

UPDATE OF COMMERCIAL SYSTEM COST ESTIMATE

The cost estimate for the commercial sized system developed during the Task 3 effort was reviewed following the receipt of preliminary cost quotations obtained for the Engineering Test Facility (Task 4). This information indicates that an upward adjustment in cost may be necessary for the mechanical and electrical systems of the commercial facility. In addition, an upward adjustment is necessary for the cost of site preparation.

Because of the nature of the Engineering Test Facility it is somewhat difficult to separate those costs that would be carried over into the commercial facility. The principal factors, however, can be summarized as follows:

- Most electrical works dealing with the data acquisition system will not be part of the commercial facility.
- Not all of the costs of equipment and labor scale upwards with the same ratio as the greenhouse growing areas ratio (15.9). (This can be seen in a general way by considering, for instance, the fact that a pump which handles 20 times more volume than another pump costs less than twice as much, and requires less than twice the man-hours to install.)
- The Engineering Test Facility is the first of its kind and much of the mechanical and electrical work, although utilizing conventional equipment and installation techniques, is adapted to a new design. As the design becomes standardized and experience is gained on the construction of a number of identical plants, the normal cost-reducing effect of the learning curve can be expected to take place.

Table B-1 shows the adjusted costs for the commercial-size system, resulting in a capital cost estimate of \$19,359,000. This should be compared with Table 4-2 of the Task 3 report showing a total capital cost of \$17,972,000. The new numbers thus represent an increase of \$1,387,000 or approximately 7.7% in capital cost. Annual costs and replacement costs remain approximately the same.

Table B-1. Subsystem Capital and Annual Costs
(to nearest thousands of dollars in 1981 dollars)

SUBSYSTEM	CAPITAL COST	ANNUAL COST	REPLACEMENT COST
PV, 344kW	642	10	
WECS, 0 kW	0	0	
Battery, 2736 KWh, 256 kW	478	11	356 after 10y
PCU, 250kW	48	1	
Diesel, 200 kW (2 units)	62	4	
Control System, UPS	400	6	
Meteorological Station	40	1	
R.O. Desalination, 304 M ³ /h	240	5	15.3 every 3y
Evaporation Pond, 7323 m ²	183	3	
CO ₂	2	242	
Subtotal	2095		
Capital Cost Adders 25% (OH, Fee, Contingency)	524		89 after 10y 3.8 every 3y
Greenhouse, 5 hectare	15730 ⁺	89	
Support Facilities	270	400 [*]	
Sitework, Fence	740 ⁺	3	
Total	19359⁺	775	439 present value

* Includes the annual salaries of all support personnel required for the entire facility.

* Increased from the Task 3 Report.

Using the fixed charge rate of 14.37%, the levelized annual cost for the commercial-size facility is increased by $0.1437 * \$1,387,000 = \$199,000/\text{yr}$. This corresponds to an increase of 4.8%, for a revised total levelized annual cost of \$4.338 M/y. The levelized produce cost is also increased by 4.8%, as summarized in Table B-2 for different crops. For example, assuming a conservative factor of two for CO_2 yields a levelized produce cost of 0.96 \$/kg or 0.44 \$/lb.

TABLE B-2. LEVELIZED PRODUCE COST FOR DIFFERENT CROPS

CROP	GOOD GREENHOUSE YIELD, Mg/ha-y	LEVELIZED PRODUCE COST, \$/kg (\$/11b)	
		CO ₂ ENRICHMENT FACTOR OF 2	CO ₂ ENRICHMENT FACTOR OF 3
CUCUMBER	450	0.96 (0.44)	0(0.29)
TOMATO	340	1.28 (0.58)	0.85 (0.39)
LETTUCE	340	1.28 (0.58)	0.85 (0.39)
WATERMELON	225	1.93 (0.87)	1.29 (0.59)
CABBAGE	180	2.41 (1.09)	1.60 (0.73)
MIX	136	3.19 (1.45)	2.13 (0.96)
BROCCOLI	78	5.57 (2.53)	3.71 (1.68)
GREEN BEANS	40	10.85 (4.92)	7.23 (3.28)

SOLAR CONTROLLED ENVIRONMENT
AGRICULTURAL SYSTEM

TASK-4

PRELIMINARY DESIGN DRAWINGS

ENGINEERING TEST FACILITY

Monday, Apr 15

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Project Management & Systems Analysis
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Texas A&M University
Agricultural Experiment Station (TAES)
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Dallas, Texas 75252

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New York, New York 10011Environmental Analysis &
Desalination System DesignUniversity of Texas at Dallas (UTD)
Box 688 Richardson, Texas 75080McCormack Corporation
P.O. Box 39848
Dallas, Texas 75238

Cost Estimating & Construction Planning

Robert E. McPhee, Inc. (REM)
P.O. Box 39848
Dallas, Texas 75238

S1 Site Plan
S2 Greenhouse Foundation Plan
S3 Structural Framing Plan
S6 Detail
S7 Indirect Support Building
S8 Indirect Support Building Sections

MP1 Site Plan (Mechanical Overlay)
M2 Roof Circulating Water System Piping
M4 CO₂ Distribution System
M8 CO₂ Distribution System (Schematic)
M10 Vent Fan Cycle Controls
M11 Support Facility-HVAC
M12 Roof Circulating Water System Equipment Layout Plan
M13 Mechanical Details
M14 Mechanical Details

P2 Water and Drainage System Plan
P3 Section 1 Plumbing Plan
P4 Section Plumbing Plan II
P5 Section Plumbing Plan III
P6 Section Plumbing Plan IV
P7 Support Facility Plumbing
P8 Fresh Water System Flow Diagram
P9 Plumbing Details (Sump Pump Septic Tank)

E1 Water and Drainage System Plan Site Plan
E2 Greenhouse Plan, Lighting
E4 Support Facility, Lighting
E5 Support Facility, Power
E6 Distribution of Panels, Solar
E7 Distribution Panels, Utility
E8 Symbols and Schedules
E9 Electrical Single Line Diagram

E01 Energy System Block and P&I Diagram
E02 PV Array Schematic
E03 PV Branch Circuit Switching
E04 PV Field Layout
E05 PV-Array Structural Support and Foundation Preliminary

C01 Control and Instrumentation System Block Diagram
C02 Growing Compartment Display and Control Panel
C03 Well Water and Roof Water Display and Control Panel
C04 Miscellaneous Systems Display and Control Panel
C04A Battery Display and Control Panel
C05 Typical Device Control Wiring
C06 Temperature Instrumentation
C08 Meteorological Station

TE-1520-B02 Reverse Osmosis P&ID
TE-1520-B03 Pretreatment P&ID
TE-1520-B04 Demineralizer P&ID

Firm Name: _____	SAI
Drawn By: _____	
Checked By: _____	Checked By: _____
Issue Date: _____	Issue Date: _____
Scale: _____	
Sheet Title: _____	No. _____

Managing Agency

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Cost Estimating & Construction Planning

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Dallas, Texas 75238

KEY

- 1 METEOROLOGICAL TOWER
- 2 INTERIOR SUPPORT BUILDING
- 3 EMPLOYEE PARKING
- 4 AIR ROOF SUPPLY DUCT
- 5 COIL TANK
- 6 P.D. TANK
- 7 LANE CORRIDOR
- 8 TRUCK DRIVE
- 9 MAINTENANCE VEHICLE APRON
- 10 HOLDING FENCE
- 11 PV ARRAY
- 12 COVERED ROOF WATER TANK, PUMP & HEAT EXCHANGER
- 13 GREENHOUSE
- 14 ACCESS ROAD
- 15 SECURITY FENCE
- 16 WELLS

SITE PLAN

KEY PLAN

2/19/82

Form Name: <u>GPA</u>	SAI
Drawn By: <u>PA</u>	
Checked By: _____	1/1/82
Issue Date: _____	Issue Date: <u>2/19/82</u>
Scale: _____	
Drawn Title: <u>SITE PLAN</u>	No. <u>S-1</u>

sceas

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New York, New York 10003

Environmental Analysis & Distribution System Layout

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McCormack Corporation
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Dallas Texas 75238

Cost Estimating & Construction Planning

Robert E. Wilson, Inc. (R&B)
P.O. Box 35648
Dallas, Texas 75238

NOTES:

1. STRENGTH OF CONCRETE AT 28 DAYS SHALL BE 3000 PSI WEIGHT - 150 PCF
2. STRENGTH OF REINFORCING STEEL SHALL BE 60,000 PSI
3. ALL STRUCTURAL STEEL SHALL BE GRADE "A" 20
4. SLAB ON GRADE (UPFLOOR "A") SHALL BE 120MM (4.8") REINFORCED WITH WWP 6x12 @ 1/2

TYPICAL COLUMN
PEDESTAL
& FOOTING DETAIL

TYPICAL INTERIOR &
EXTERIOR FIN. WALL
DETAIL

FOUNDATION PLAN

SCALE: 1/2" = 1'-0"

FOOTING SCHEDULE

FOOTING MARK	ALLOW SOIL BEARING PRESSURE = 2000 PSF	ALLOW SOIL BEARING PRESSURE = 4000 PSF
	SIZE / REBAR	SIZE / REBAR
TYPE 1	5'-0" x 5'-0" x 1'-0" W/ 3 #4 @ 12"	5'-0" x 5'-0" x 1'-0" W/ 3 #4 @ 12"
TYPE 2	7'-0" x 7'-0" x 1'-0" W/ 3 #4 @ 12"	5'-0" x 5'-0" x 1'-0" W/ 3 #4 @ 12"

PROGRESS PRINT 2/16/82

Form Name <u>SR-1</u>	SAI
Drawn By <u>PL</u>	
Checked By _____	Checked By <u>PL</u>
Issue Date _____	Issue Date <u>4/11/82</u>
Scale <u>1/2"</u>	
Sheet Title GREENHOUSE FOUNDATION PLAN	No. <u>S-2</u>

sceas

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NOTES:

1. THE DESIGN IS FOR COLUMN SIZES.
2. STRENGTH OF ALL STRUCTURAL STEEL SHALL BE F_y = 36 ksi (GRADE A36).
3. ALL BOLTS FOR STRUCTURAL STEEL SHALL BE 1/2" A325.

STRUCTURAL FRAMING PLAN

PROGRESS PRINT 4/14/82

File Name: <u>SP4</u>	SAI
Drawn By: <u>FAI</u>	
Checked By: _____	Checked By: <u>Hse</u>
Issue Date: _____	Issue Date: <u>4/14/82</u>
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Sheet Title: <u>STRUCTURAL FRAMING PLAN</u>	No. <u>5-3</u>

DETAIL 'A'

PROGRESS PRINT 2/1/02

A SOLERAS PROJECT

sceas

Managing Agents

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Distribution System Design

University of Texas at Dallas (UTD)
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McCormack Construction
P.O. Box 38845
Dallas, Texas 75228

Cost Estimating & Construction Planning

Robert E. McPherson, Inc. (REMI)
P.O. Box 35848
Dallas, Texas 75228

SOLAR
CONTROLLED
ENVIRONMENT
AGRICULTURE
SYSTEM
SC-EAS

Form Name <u>SBA</u>	SAI
Drawn By <u>PAU</u>	
Checked By _____	Checked By <u>Hse</u>
Issue Date _____	Issue Date <u>2/1/02</u>
Scale _____	
Sheet Title DETAILS	No. S-6

Managing Agents

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants

Project Management & Systems Analysis
Energy, Mechanical & Electrical Systems Design
Phase 2 Planning

Science Applications, Inc.
1710 Goodridge Drive
McLean, Virginia 22101

Zimmer & Vetter, Inc. (S&V Submitter)
1330 River Road Dr
Dallas, Texas 75247

Agricultural & Greenhouse Planning

Texas A & M University
Agricultural Experiment Station (TAES)
17360 East Road,
Dallas, Texas 75252

Architectural & Structural Design

Gasper Burger Associates, P.C. (GABA)
714 Park Ave
New York, New York 10021

Environmental Analysis & Distribution System Design

University of Texas at Dallas (UTD)
Box 6095 Richardson, Texas 75080

• McCarrick Corporation
P.O. Box 38645
Dallas, Texas 75226

Cost Estimating & Construction Planning

Robert L. McNamee, Inc./ RLM
P.O. Box 25848
Dallas, Texas 75226

PROGRESS PRINT 2/10/02

Firm Name <u>SAI</u> Drawn By <u>SAI</u> Checked By _____ Issue Date _____ Scale <u>1:100</u>	SAI Checked by <u>H.H.</u> Issue date <u>4/1</u>
Show "are INQUIRY SUPPORT BLDG	to S 7 1

sceas

Managing Agents

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants

Project Management & Systems Analysis
Energy, Mechanical & Electrical Systems Design
Phase 2 Planning

Science Applications, Inc.
1710 Greenbridge Drive
McLean, Virginia 22102

Zumwalt & Vothel, Inc. (SAI Subsidiary)
3330 River Street Dr.
Dallas, Texas 75247

Agricultural & Greenhouse Planning

Texas A&M University
Agricultural Experiment Station (TAES)
17300, East Road
Dallas, Texas 75233

Architectural & Structural Design

Gasper, Berger Associates, P.C. (SBA)
704 First Ave.
New York, New York 10001

Environmental Analysis &
Designation System Design

University of Texas at Dallas (UTD)
Box 808 Richardson, Texas 75080

McCormack Corporation
P.O. Box 35545
Dallas, Texas 75225

Cost Estimating & Construction Planning

Robert E. McPherson, Inc. (REM)
P.O. Box 35545
Dallas, Texas 75225

CONTROLLED ENVIRONMENT AGRICULTURE SYSTEMS

LINK CORR. SECTION
SCALE: 1/8" = 1'-0"

TYPICAL CROSS SECTION
SCALE: 1/8" = 1'-0"

PROGRESS PRINT 2/10/02

Firm Name: <u>SAI</u>	SAI
Drawn By: <u>YT</u>	
Checked By: _____	Checked By: <u>HSC</u>
Issue Date: _____	Issue Date: <u>2/10/02</u>
Scale: <u>AS SHOWN</u>	
Sheet Title: <u>INDIRECT SUPPORT BLDG. SECTIONS</u>	No. <u>S-8</u>

Solar Energy Research Institute S E R I
1617 Cole Boulevard
Golden, Colorado 80401

1. Subject: Mathematics
 2. Topic: Algebra
 3. Section: Algebra

Science Applications Inc.
1710 Lonsdale Drive
McLean, Virginia 22102

Zumwalt & Voth Inc. (SA) Subsidiary
1330 River Bend Dr.
Dallas Texas 75241

Texas A&M University
Agricultural Experiment Station (TAES)
17360 Coit Road
Dallas Texas 75252

Chapman, Berger Associates PC HQBA
714 Fifth Ave
New York New York 10011

University of Texas at Dallas (UTD)
Box 668 Richardson Texas 75080

Bill Carmack Corporation
P.O. Box 1864
Dallas Texas 75238

Robert E. McKee Inc. IRE M.
P.O. Box 3584H
Dallas Texas 75235

```

1  - MATHS/COMB/ALG/GEOM/STATS
2  - MATHS/COMB/ALG/GEOM/STATS
3  - MATHS/COMB/ALG/GEOM/STATS
4  - MATHS/COMB/ALG/GEOM/STATS
5  - MATHS/COMB/ALG/GEOM/STATS
6  - MATHS/COMB/ALG/GEOM/STATS
7  - MATHS/COMB/ALG/GEOM/STATS
8  - MATHS/COMB/ALG/GEOM/STATS
9  - MATHS/COMB/ALG/GEOM/STATS
10 - MATHS/COMB/ALG/GEOM/STATS
11 - MATHS/COMB/ALG/GEOM/STATS
12 - MATHS/COMB/ALG/GEOM/STATS
13 - MATHS/COMB/ALG/GEOM/STATS
14 - MATHS/COMB/ALG/GEOM/STATS
15 - MATHS/COMB/ALG/GEOM/STATS
16 - MATHS/COMB/ALG/GEOM/STATS
17 - MATHS/COMB/ALG/GEOM/STATS
18 - MATHS/COMB/ALG/GEOM/STATS
19 - MATHS/COMB/ALG/GEOM/STATS
20 - MATHS/COMB/ALG/GEOM/STATS

```

SITE PLAN
SCALE 1"=50'-0"

KEY PLAN
SCALE 1"=400'-0"

Form Name <u>ZE</u> Division <u>B</u> <u>13W</u> Date Rec'd <u>12-11-77</u> Rec'd Date <u>12-11-77</u> Serial # <u>100</u> Stamp # <u>100</u>	SAI Date Rec'd <u>12-11-77</u> Rec'd Date <u>12-11-77</u> MP-1

sceas

Manufacturing Agency

Solar Energy Research Institute (SERI)
1617 Loop Southwest
Golden, Colorado 80401

Project Participants

Project: Mission Project & Systems Analysis
Energy: Mechanical & Electrical Systems Laboratory
Power: Electrical

Science Applications, Inc.
1710 Goodridge Drive
McLean, Virginia 22102

Zachry & Voth, Inc. (S&V Subcontractors)
1230 River Bend Dr.
Dallas, Texas 75247

Agricultural & Livestock Planning

Texas A&M University
Agricultural Experiment Station (A&E)
17380 East Road
Dallas, Texas 75252

Architectural & Structural Issues

Georgi Berger Associates PC (GBA)
114 17th Ave.
New York, New York 10011

Environmental Analysis &
Designation System Users

University of Texas at Dallas (UTD)
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McCormick Corporation
P.O. Box 38845
Dallas, Texas 75238

Cost Estimating & Construction Planning

Robert E. McRae Inc. (REMI)
P.O. Box 38848
Dallas, Texas 75238

ROOF CIRCULATING WATER SYSTEM PIPING

Form Name: <u>ZAS</u>	
Drawn By: <u>RC</u>	
Checked By: <u>RR</u>	
Issue Date: <u>2-15-90</u>	
Scale: <u>1" = 5'</u>	
Sheet Title:	M-2

sceas

Marketing Agency

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants

Project Management & Systems Analysis
Energy Management & Electrical Systems (EMES)
Phase 2: Design

System Applications Inc.
1710 Goodridge Drive
McLean, Virginia 22102

Zimmerli & Voth, Inc. (IBM Subcontractor)
1330 River Bend Dr.
Dallas, Texas 75247

Agricultural & Greenhouse Partner

Texas A&M University
Agricultural Experiment Station TAE-5
17380 Coit Road
Dallas, Texas 75252

Architectural & Structural Units

Galper Berger Associates, PC (GBA)
945 7th Ave.
New York, New York 10011

Environmental Analysis & Distribution System Units

University of Texas at Dallas (UTD)
Box 808, Richardson, Texas 75081

McCormack Corporation
P.O. Box 38844
Dallas, Texas 75238

Cost Estimating & Construction Partner

Robert E. Spence Inc. (RESI)
P.O. Box 38844
Dallas, Texas 75238

CO₂ DISTRIBUTION SYSTEM

Exam Name: <u>E&V</u> Drawn By: <u>RC</u> Checked By: <u>RR</u> Issue Date: <u>2-25-81</u> Scale: <u>1"=5'0"</u>	SAI Checked: <u>RR</u> Issue Date: <u>2-25-81</u>
Sheet Title: <u>M-4</u>	

sceas

Marketing Agent:

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants:

Phase 1: Minnesota R. Systems Analysis
Energy, Materials and Environmental Engineering
Phase 2: Phase 2

Science Applications Inc.
1740 Good Hope Drive
McLean, Virginia 22102

Zimmerman & Vetter, Inc. (SAI) Subsidiary
6330 River Bend Dr.
Dallas, Texas 75247

Agricultural & Greenhouse Planning:

Texas A&M University
Agricultural Experiment Station (AES)
17360 Coll Road
Dallas, Texas 75252

Architectural & Structural Design:

Georg Berger Associates PC (GBA)
114 Fifth Ave.
New York, New York 10011

Environmental Analysis:
Operational System Design:

University of Texas at Dallas (UTD)
Box 688 Richardson, Texas 75080

McCormack Construction
P.O. Box 38045
Dallas, Texas 75238

Cost Estimating & Construction Planning:

Robert E. Wynn, Inc. (REMI)
P.O. Box 38045
Dallas, Texas 75238

CO₂ DISTRIBUTION SYSTEM
NO SCALE

Form Number: SAI	SAI
Drawn By: SAI	
Checked By: SAI	
Issue Date: 12-8-81	
Scale:	
Sheet Title:	
	M 8

sceas

Member Agency

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants

Project Management & Systems Analysis
Energy Management & Control Systems (EMCS)
Project 2: Design

Science Applications Inc.
1710 Grindridge Drive
McLean, Virginia 22102

Zumwalt & Vance, Inc. (BAI) Subsidiary
5330 River Bend Dr.
Dallas, Texas 75247

Agriculture & Greenhouse Physics

Texas A&M University
Agricultural Experiment Station (AES)
17300 Coit Road
Dallas, Texas 75252

Architectural & Structural Design

Garage Design Associates PC (GDA)
154 Fifth Ave.
New York, New York 10011

Environmental Analysis &
Design/Build Systems (EAS)

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McCormick Corporation
P.O. Box 30845
Dallas, Texas 75230

Cost Estimating & Construction Planning

Robert E. Gifford Inc. (REMI)
P.O. Box 35848
Dallas, Texas 75235

VENT FAN CYCLE CONTROLS

NO SCALE

Drawn By: <u>LL</u>	Check By: <u>LL</u>
Drawn By: <u>R</u>	Check By: <u>LL</u>
Issue Date: <u>1-15-82</u>	Issue Date: <u>1-15-82</u>
Sheet No.	Sheet No.
M-10	

Managing Agents

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants

Project Management & Systems Analysis
Energy, Mechanical & Electrical Systems Group
Phase 2 Planning

Science Applications, Inc.
1710 Goodridge Drive
McLean, Virginia 22102

Zumwalt & Voth, Inc. (SAI Subsidiary)
1330 River Bend Dr.
Dallas, Texas 75247

Agricultural & Greenhouse Planning

Texas A&M University
Agricultural Experiment Station (TAES)
17350 Coit Road
Dallas, Texas 75252

Architectural & Structural Design

Geiger Berger Associates, P.C. (GBA)
194 Fifth Ave.
New York, New York 10011

Environmental Analysis & Design/Service System Design

University of Texas at Dallas (UTDI)
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McCormick Corporation
P.O. Box 38645
Dallas, Texas 75248

Cost Estimating & Construction Planning

Robert E. Mikes, Inc. (REM)
P.O. Box 35648
Dallas, Texas 75235

SOLAR
CONTROLLED
ENVIRONMENT
AGRICULTURE
SYSTEM
SC-EAS

SUPPORT FACILITY - HVAC

INDIRECT SUPPORT BLDG.
1100

4/8/81	Firm Name <u>Z&V</u>	SAI
4/8/81	Drawn by <u>RL</u>	
	Checked by <u>RR</u>	
2/9/81	Issue Date <u>2-25-81</u>	
1/10/81	Scale <u>1\"/> </u>	

No.
M-11

sceas

Marketing Agents:

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants:

Project Management & Systems Analysis
Energy, Mechanical & Electrical Systems Group
P.O. Box 1000

Science Applications Inc.
1715 Goodridge Drive
McLean, Virginia 22102

Zumwalt & Voth Inc. (SAS) Subsidiary
1310 River Bend Dr.
Dallas, Texas 75247

Agricultural & Urban Planning:

Texas A&M University
Agricultural Experiment Station (AES)
17350 East Road
Dallas, Texas 75252

Architectural & Structural Design:

Ginger Berger Associates PC, SBA
104 Fifth Ave.
New York, New York 10003

Environmental Analysis &
Design/Construction:

University of Texas at Dallas (UTD)
Box 988 Richardson Texas 75081

McClure & Corporation
P.O. Box 380-45
Dallas, Texas 75238

Cost Estimating & Construction Planning:

Robert E. Griffin Inc. (REI)
P.O. Box 380-45
Dallas, Texas 75238

NOTE

RCWS - ROOF CIRCULATING WATER SUPPLY
RCWR - ROOF CIRCULATING WATER RETURN
WWS - WELL WATER SUPPLY
WWR - WELL WATER RETURN

ROOF CIRCULATING WATER SYSTEM EQUIPMENT LAYOUT PLAN

SCALE - 1/4" = 1'-0"

ELEVATION A-A

PIPING SYSTEM	MATERIAL
ROOF CIRC. WATER	PVC SCH. 40
WELL WATER	PVC SCH. 40
DEHUMIDIFICATION	PVC SCH. 40
HEAT	PVC SCH. 40
CHILLED WATER	PVC SCH. 40
CARBON DIOXIDE	PVC SCH. 40

Form Name - <u>Z & Y</u>	SA
Drawn By - <u>P.C.</u>	
Checked By - <u>B.R.</u>	
Issue Date - <u>2.2.90</u>	
Scale - <u>1/4" = 1'-0"</u>	
Sheet No.	M-12

sceas

Measuring Agent

Texas Energy Research Institute, Inc. P.O. Box 16177
Cedar Rapids, Iowa 52416

Process Manufacturer

Process Manufacturer & Systems, Inc.
Energy, Mechanical & Electrical Engineering
Houston, Texas

Science Applications, Inc.
1740 Concho Ridge Drive
McLean, Virginia 22102

Zimmerman & Voth, Inc. (S&I Subsidiary)
5330 River Bend Dr.
Dallas, Texas 75247

Agricultural & Landowner Partners

Brack A&M University
Agricultural Experiment Station T&E
17360 East Road
Dallas, Texas 75247

Architectural & Structural Engineers

Ginger, Berger, Associates, P.C. (S&I)
194 Fifth Ave.
New York, New York 10011

Environmental Analysis

Development, Systems, Inc.
University of Texas at Dallas
Box 606 Richardson, Texas 75080

McCormack Corporation
P.O. Box 18845
Dallas, Texas 75238

Cost Estimating & Construction Services

Robert E. McLean Inc. (REM)
P.O. Box 15848
Dallas, Texas 75235

VALVE SCHEDULE

✕	GATE VALVE NORMALLY OPEN
✕	GATE VALVE NORMALLY CLOSED
✕	GLUE VALVE NORMALLY OPEN
✕	GLUE VALVE NORMALLY CLOSED
✕	VALVE TO BE OPERATED MANUALLY
✕	THREE WAY VALVE
✕	FLANGING VALVE
✕	CHECK VALVE
✕	STOP CHECK VALVE
✕	ANNEAL VALVE
✕	RELIEF VALVE
✕	SMALL BALL VALVE
✕	FLANGING OPERATED VALVE
✕	METRIC VALVE
✕	CLAMPING VALVE TO BE OPENED
✕	ALUMINUM VALVE
✕	BUTTERFLY VALVE NORMALLY OPEN
✕	BUTTERFLY VALVE NORMALLY CLOSED
✕	VENT VALVE
✕	WATER VALVE

VERTICAL TURBINE WELL PUMP DETAIL
NO SCALE

PUMP PIPING DETAIL
NO SCALE

AIR INTAKE / RELIEF HOOD DETAIL
NO SCALE

**DETAIL OF DOME TYPE
FAN WITH STANDARD CURB**
NO SCALE

**PIPING OF SINGLE WATER COIL WITH
AUTOMATIC CONTROL**
NO SCALE

PIPING OF HW REHEAT COIL
NO SCALE

WALL MOUNTED EXHAUST FAN
NO SCALE

Form Number: ZS-1	Scale: 1/4\"
Drawn By: J. L.	Checked By: H. L.
Chief Engineer: R. L.	Project Engineer: H. L.
Rev. No: ZS-1 P. 1	Rev. No: H. L.
Scale: 1/4\"	Scale: 1/4\"
Sheet Title: NO SCALE	Sheet Title: NO SCALE

M-13

[illegible]

SECTION "A-A"

DETAIL OF EQUIPMENT FOUNDATION
REQUIRING SPRING ISOLATED INERTIA BASE
NO SCALE

ROOF CIRCULATING WATER HEADER
ELEVATION

SCALE 1 1/2" = 1'-0"

Solar Energy Research Institute, Inc.
1617 Cole Boulevard
Golden, Colorado 80401

High 1. Most good & systems. And
Energy. Most good & systems. And
Energy. Most good & systems. And

Science Applications, Inc.
1710 Goodridge Drive
McLean, Virginia 22102

Zimmerli & Voth, Inc. (SA) Subcontractor
1330 River Bend Dr.
Dallas, Texas 75247

Texas A&M University,
Agricultural Experiment Station TAF
17360 Coit Road
Dallas Texas 75257

Genger Benger Associates PC, K&A
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New York, New York 10011

University of Texas at Dallas (UTD)
Box 868 Richardson Texas 75080

McCormack Corporation
P.O. Box 38645
Dallas, Texas 75238

Robert E. McInnis Inc (REMI)
P.O. Box 35848
Dallas, Texas 75235

Form Name: <u>SAI</u>	SAI
Document ID: _____	
Classified By: _____	_____
Release Date: <u>1-25-01</u>	_____
Signature: _____	
Stamp Title: _____	M-14

sceas

Memorandum Agency

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project: Part 1/2/3/4/5/6/7/8/9/10

Project: Measurement & Systems Analysis
Energy: Measurement & Systems Analysis
Project: Measurement

Science Applications Inc.
1710 Goodridge Drive
McLean, Virginia 22102

Zumwalt & Voth Inc. (SAI Subsidiary)
1330 River Bend Dr.
Dallas, Texas 75247

Agricultural & Greenhouse Planning

Texas A&M University
Agricultural Experiment Station (AES)
17350 Coll. Road
Dallas, Texas 75232

Architectural & Structural Design

Georg Berger Associates Inc. (GBA)
14 Fifth Ave.
New York, New York 10011

Environmental Analysis & Distribution System Design

University of Texas at Dallas (UTD)
Box 688 Richardson, Texas 75080

McCombs Construction
P.O. Box 16645
Dallas, Texas 75226

Cost Estimating & Construction Planning

Robert E. Wilson Inc. (REI)
P.O. Box 20648
Dallas, Texas 75226

18

WATER & DRAINAGE SYSTEM PLAN

NOTE: PROVIDE & INSTALL RE-ROOF DRAIN (E.D.) AS SPECIFIED

Firm Name: SBV	SAI
Drawn By: C.S.	
Checked By: D.L.M.	Checked By: D.L.M.
Issue Date: 1/1/81	Issue Date: 1/1/81
Scale: 1" = 8'-0"	
Sheet Title:	

Managers, Agents

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants

Project Management & Construction Services
Engineering, Architecture & Construction Services
Houston, Texas

Service Applications Inc.
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McLean, Virginia 22102
Zumwalt & Voth, Inc. (SAI) Subsidiary
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Dallas, Texas 75247

Agricultural & Environmental Sciences

Texas A&M University
Agricultural Experiment Station TAFS
17360 Coit Road
Dallas, Texas 75232

Architectural & Structural Services

Garner Berger Associates PC (GBA)
114 Fifth Ave.
New York, New York 10011

Environmental Analysis &
Regulation Systems (EARS)

University of Texas at Dallas (UTD)
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McCormack Corporation
P.O. Box 38645
Dallas, Texas 75238

Cost Estimating & Construction Planning

Robert E. McFarlane Inc. (REMI)
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Dallas, Texas 75235

SECTION I PLUMBING PLAN

Task Name: 247	SAI
Drawn By: C.S.	
Checked By: D.A.	
Issue Date: 1/1/82	
Scale: 1/4" = 1'-0"	
Sheet No: P-3	

sceas

Memphis, April

State Energy Research Institute, S.E.R.I.
1617 Camp Boulevard
Garden, Colorado 80401

Project Description:

Project Management & Systems Analysis
Energy, Mechanical & Environmental Engineering
Phase 2: Design

Science Applications Inc.
1710 Greenbridge Drive
McLean, Virginia 22102

Zimmerman & Voth, Inc. (SAI) Subsidiary
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Dallas, Texas 75241

Agricultural & Greenhouse Planning

Texas A&M University
Agricultural Experiment Station T&ES
17300 East Road
Dallas, Texas 75257

Architectural & Structural Design

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New York, New York 10011

Environmental Analysis
Environmental Systems Design

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Dallas, Texas 75238

Cost Estimating & Construction Planning

Robert E. McPherson Inc. (REM)
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Dallas, Texas 75238

SECTION II PLUMBING PLAN

Plan No.	20	QA
Drawn by	20	
Checked by	20	
Issue Date		
Scale		
Sheet No.		

March 1971

Small Energy Research Institute, S.E. 111
1617 (1st) Boulevard
Golden, Colorado 80401

Project: 11111111

Project: 11111111, 11111111, 11111111
Project: 11111111, 11111111, 11111111
Project: 11111111, 11111111, 11111111

Science Applications Inc.
1710 Landridge Drive
McLean, Virginia 22102

Zumwalt & Voth, Inc. (SA) Subsidiary
5330 River Bend Dr.
Dallas, Texas 75247

Agricultural & Environmental Services

Texas A&M University
Agricultural Experiment Station (TAE)
17390 Cort Road
Dallas, Texas 75252

Architectural & Structural Services

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New York, New York 10011

Environmental Services
Distribution System Service

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Box 600 Richardson Texas 75081

McCormack Corporation
P.O. Box 38645
Dallas, Texas 75238

Cost Estimating & Construction Services

Robert E. McLean Inc. (REMI)
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Dallas, Texas 75238

SECTION III PLUMBING PLAN

Form Name: 111111	SAI
Drawn By: 111111	
Checked By: 111111	
Rev. Date: 111111	
Scale: 111111	
Sheet No: 111111	
Sheet Title: 111111	
P-5	

sceas

Managing Agent:

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants:

Project Management & Systems Analysis
Energy Management & Design Institute
Project 2: Planning

Science Applications Inc.
1710 Goodridge Drive
McLean, Virginia 22102

Zumwalt & Vothler, Inc. (SAI Subsidiary)
1330 River Bend Dr.
Dallas, Texas 75247

Agricultural & Environmental Planning

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Agricultural Experiment Station (TAES)
17360 Coit Road
Dallas, Texas 75232

Architectural & Structural Design

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New York, New York 10011

Environmental Analysis &

Distribution System Design
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Box 686 Richardson, Texas 75080

McCormack Corporation
P.O. Box 38645
Dallas, Texas 75238

Cost Estimating & Construction Planning

Robert E. Blythe Inc. (REMI)
P.O. Box 33646
Dallas, Texas 75236

SECTION IV PLUMBING PLAN

Form Name: <u>SAI</u>	SAI
Drawn By: <u>CS</u>	
Checked By: <u>DL</u>	Checked By: <u>DL</u>
Issue Date: <u>11/1/82</u>	Issue Date: <u>11/1/82</u>
Scale: <u>1/4" = 1'</u>	
Sheet Title:	
P-6	

Mortgage Agents

Solar Energy Research Institute (SERI)
2817 Cedar Boulevard
Golden, Colorado 80401

Project Participants

**Project Management & Systems Analysis
Energy, Mechanical & Electrical Systems-Design,
Phase 2 Planning**

Science Applications, Inc.
1710 Cambridge Drive,
Bellevue, Virginia 22061

Summitt & Vetter, Inc. 8540 Gentryway
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Dallas, Texas 75247

Agricultural & Greenhouse Planning

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Agricultural Experiment Station (TAR-2)
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Dallas, Texas 75242

Architectural & Structural Design

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New York, New York 10017

Environmental Analysis & Construction Systems Design

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Box 088 Richardson, Texas 75080

McGraw-Hill, Corporation
P.O. Box 248-48
Saddle River, New Jersey 07671

Cost Estimating & Construction Phases

Robert E. McLean, Inc. (70200)
P.O. Box 200-00
Dallas, Texas 75200

Firm Name <u>REY</u> Drawn By <u>SS</u> Checked By <u>ALM</u> Issue Date <u>2-19-02</u> Scale <u>1/2" = 1'</u> Sheet Title	SAI Checked By <u>LS</u> Issue Date <u>2/14</u> No. <u>1-7</u>

sceas

Marketing Agent:

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants:

Phase 1: Architecture & Systems Analysis
Energy, Mechanical & Electrical Systems Design
Phase 2: Planning

Science Applications, Inc.
1740 Goodridge Drive
McLean, Virginia 22102

Zumwalt & Vothler, Inc. (SAI Subsidiary)
5330 River Bend Dr.
Dallas, Texas 75247

Agricultural & Commercial Planning:

Texas A&M University
Agricultural Experiment Station TAE-5
17360 Coit Road
Dallas, Texas 75252

Architectural & Structural Design:

Ginger Burger Associates, P.C. (GSA)
141 First Ave.
New York, New York 10011

Environmental Analysis & Insulation System Design:

University of Texas at Dallas (UTD)
Box 988 Richardson, Texas 75081

McCormack Construction
P.O. Box 34645
Dallas, Texas 75238

Cost Estimating & Construction Planning:

Robert E. Maffei Inc. (REM)
P.O. Box 36848
Dallas, Texas 75236

TYPICAL DRAINAGE FIELD TRENCH

WATER HEATER PIPING DIAGRAM

DRAINAGE FIELD PIPING DIAGRAM

FRESH WATER SYSTEM FLOW DIAGRAM

Form Name	SAI
Drawn By	C.S.
Checked By	D.L.W.
Issue Date	2-25-83
Scale	None
Sheet No.	P-8

Multiple Agency

State Energy Research Institute (SERI)
1617 Cook Boulevard
Golden, Colorado 80401

Power Engineering

Power Engineering Associates, Inc.
10000 North Central Expressway
Dallas, Texas 75243

Science Applications, Inc.
1710 Goodridge Drive
McLean, Virginia 22102

Zumwalt & Voth, Inc. (SAI Subsidiary)
1330 River Bend Dr.
Dallas, Texas 75247

Agribusiness & Cooperative Extension

Texas A&M University
Agricultural Experiment Station (AES)
17300 Coit Road
Dallas, Texas 75252

Architectural & Structural Engineering

Georgi, Berger Associates, PC (GBA)
116 11th Ave.
New York, New York 10011

Environmental Analysis
Environmental Systems, Inc.

University of Texas at Dallas (UTD)
Box 688 Richardson Texas 75080

McCormack Corporation
P.O. Box 38645
Dallas, Texas 75238

Robert E. McKeown, Inc.

Robert E. McKeown, Inc. (REM)
P.O. Box 35845
Dallas, Texas 75235

RISER DIAGRAMS

PLAN

SECTION

SEPTIC TANK DETAIL

WATER PRESSURE SYSTEM											
LINE NO.	FROM	TO	SIZE	VALVE	TYPE	DATE	BY	CHKD	APP'D	REV	REMARKS
1	MAIN	100'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	1	INSTALL
2	100'	200'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	2	INSTALL
3	200'	300'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	3	INSTALL
4	300'	400'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	4	INSTALL
5	400'	500'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	5	INSTALL
6	500'	600'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	6	INSTALL
7	600'	700'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	7	INSTALL
8	700'	800'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	8	INSTALL
9	800'	900'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	9	INSTALL
10	900'	1000'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	10	INSTALL

CONTINUED

LINE NO.	FROM	TO	SIZE	VALVE	TYPE	DATE	BY	CHKD	APP'D	REV	REMARKS
11	1000'	1100'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	11	INSTALL
12	1100'	1200'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	12	INSTALL
13	1200'	1300'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	13	INSTALL
14	1300'	1400'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	14	INSTALL
15	1400'	1500'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	15	INSTALL

VALVE BOX DETAIL

SUMP PUMP SCHEDULE

LINE NO.	FROM	TO	SIZE	VALVE	TYPE	DATE	BY	CHKD	APP'D	REV	REMARKS
16	1500'	1600'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	16	INSTALL
17	1600'	1700'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	17	INSTALL
18	1700'	1800'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	18	INSTALL
19	1800'	1900'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	19	INSTALL
20	1900'	2000'	12"	1"	1"	10/1/75	J.M.	J.M.	J.M.	20	INSTALL

Line No. 20	SAI
Drawn By: C.S.	
Checked By: D.B.	
Rev. Date: 10/1/75	
Notes: SUMP	
Sheet No. 1	P-9

•

1

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4

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- 1 -

1. ADDITIONAL DISCLOSURE INDICATES, CIRCUMSTANCES AROUND THE 1980S AND 1990S IN THE LOCALITIES

J. MORGAN & SONS LTD (206) PO BOX 110000 PLUG COMPTON

8. INITIALS, TYPE, & POSITION OF TOP OF STATIONARY FORCE. POSITION, ADDRESS, DATE OF ASSESSMENT, NUMBER OF STATIONS IN FORCE, "SLA" AND COMMENTS. FROM THIS COM'G. NOW.

ALL INFORMATION CONTAINED HEREIN IS UNCLASSIFIED

SCALE 1' 50"

SEAL 1-400 (1)

sceas

DATE

 1. BOARD NO. 60007. BY AND LOCATIONS
 AND FINISHES ADDRESS THIS BOARD

Managing Agency:

 Solar Energy Research Institute (SERI)
 1617 Crisp Boulevard
 Golden, Colorado 80401

Project Participants:

 Project Management & Systems Analysis
 Energy Management Systems Institute
 Project 2, Phoenix

 Science Applications Inc.
 1740 Goodridge Drive
 McLean, Virginia 22102

 Zimmell & Voth, Inc. (SAI Subsidiary)
 5330 River Bend Dr.
 Dallas, Texas 75247

Agricultural & Greenhouse Planning:

 Texas A&M University
 Agricultural Experiment Station TAE-5
 17360 Coit Road
 Dallas, Texas 75242

Architectural & Structural Design:

 Genger Burger Associates PC (GBA)
 144 Fifth Ave.
 New York, New York 10011
Environmental Analysis &
Diagnostic System (EAS)
 University of Texas at Dallas (UTD)
 Box 600 Richardson, Texas 75080

 McCormack Corporation
 P.O. Box 30645
 Dallas, Texas 75230

Cost Estimating & Construction Planning:

 Robert E. Mikes Inc. (REMI)
 P.O. Box 30648
 Dallas, Texas 75230

GREENHOUSE PLAN - LIGHTING

Form No.	24V	SAI
Drawn By	DRA	
Checked By	BJ	
Issue Date	5-18-88	
Scale	1"=5ft	Drawn By: <i>BJ</i> Issue Date: <i>5/18/88</i> Scale: <i>1/1</i>
Sheet No.		E-2

Managing Agents:

Ohio Energy Research Institute (OERI)
817 Oak Boulevard
Columbus, Ohio 43201

Project Participants:

Project Management & Systems Analysis
Energy, Mechanical & Electrical Systems Design
Phase 2, Planning

Science Applications, Inc.
7710 Goodridge Drive,
McLean, Virginia 22102

Zimmer & Voth, Inc. (SAI Subsidiary)
2230 River Road Dr.
Dallas, Texas 75247

Agricultural & Greenhouse Planning

Texas A&M University
Agricultural Experiment Station (AES)
17500 Oak Road,
Dallas, Texas 75242

Architectural & Structural Design

Galaxy Design Associates, Inc. (SDA)
764 Park Ave.
New York, New York 10016

Environmental Analysis & Distribution System Design

University of Texas at Dallas (UTD)
Box 888 Richardson, Texas 75080

McCombs Corporation
P.O. Box 200-45
Dallas, Texas 75202

Cost Estimating & Construction Planning

Robert E. Griffin, Inc. (REI)
P.O. Box 200-45
Dallas, Texas 75202

SUPPORT FACILITY LIGHTING

NOTES:

1. LIGHTING FIXTURES (TYPE A) SHOWN ON THIS SHEET SHALL BE SUPPLIED FROM CIRCUIT 250-1.
2. LIGHTING FIXTURES (TYPE A) SHOWN ON THIS SHEET SHALL BE SUPPLIED FROM CIRCUIT 250-2. LIGHTING FIXTURES (TYPE B) SHOWN ON THIS SHEET SHALL BE SUPPLIED FROM CIRCUIT 250-3.
3. LIGHTING FIXTURES (TYPE C) SHOWN ON THIS SHEET SHALL BE SUPPLIED FROM CIRCUIT 250-4.
4. LIGHTING FIXTURES (TYPE D) SHOWN ON THIS SHEET SHALL BE SUPPLIED FROM CIRCUIT 250-5.
5. LIGHTING FIXTURES (TYPE E) SHOWN ON THIS SHEET SHALL BE SUPPLIED FROM CIRCUIT 250-6.

File Name	25V	SAI
Drawn By	D.R.A.	
Checked By	B.M.	Checked By
Issue Date	2-12-71	Issue Date
Scale	1:500	
Sheet Title	No	
	E-4	

Managing Agents

Solar Energy Research Institute (SERI)
3717 Cook Boulevard
Golden, Colorado 80401

Project Participants

Project Management & Systems Analysis
Planning, Engineering & Electrical Systems Design
Energy Planning

Solar Applications
1700 Rockledge Drive
Boulder, Colorado 80501

Research & Utilization, Inc. (RAU) (contracted)
1000 West 10th St.
Boulder, Colorado 80502

Architect & Greenhouse Planning

State A&E University
Department of Architecture (DAE)
1700 Cook Road
Boulder, Colorado 80501

Architectural & Structural Design

State A&E University, Inc. (SAU)
1700 Cook Road
Boulder, Colorado 80501

Structural Analysis & Foundation System Design

University of Texas at San Antonio
San Antonio, Texas 78205

Dr. Charles C. Cramer
P.O. Box 10000
Boulder, Colorado 80501

Cost Estimating & Construction Planning

State A&E University, Inc. (SAU)
1700 Cook Road
Boulder, Colorado 80501

ELECTRIC AND EQUIPMENT LAYOUT

SYSTEMS

DESIGN

PLAN

SECTION

DETAIL

ASSEMBLY

GENERAL

SUPPORT FACILITY - POWER

Fig. No.	24V	SAI
Drawn By	D.R.G.	
Checked By	B.H.	Checked By <i>10/10</i>
Date	2-22-82	Date <i>10/10</i>
Scale	1"=10'	
Sheet No.		No.
		F-8

sceas

Membership Agency

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants

Project Management & Systems Analysis
Energy Management Systems (EMS)
Project Participants

Science Applications Inc.
1710 Goodridge Drive
McLean, Virginia 22102

Zumwalt & Vothler, Inc. (SAI) Subcontractor
1330 River Bend Dr.
Dallas, Texas 75247

Agricultural & Horticultural Planning

Texas A&M University
Agricultural Experiment Station TAE-5
17360 Carl Road
Dallas, Texas 75252

Architectural & Structural Design

Design Group Associates PC (DGA)
194 Fifth Ave.
New York, New York 10011

Environmental Analysis &
Laboratory System Users

University of Texas at Dallas (UTD)
Box 688 Richardson Texas 75080

McCormack Corporation
P.O. Box 38645
Dallas Texas 75238

Cost Estimating & Construction Planning

Robert E. Hoffman Inc. (REH)
P.O. Box 38648
Dallas Texas 75238

NOTES

1. POSITION ALL STARTED UNITS WITH DATA UNITS AND 1
DAY - COMPLETE INSTALLATION FOR CONNECTION TO DATA
SYSTEMS

PANEL "DPHA"									
NO.	SERIES	STARTED DATE	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	REMARKS
1	DPH 1	7.5	0.012	12"	0.012	0.012	0.012	0.012	VARIABLE SPEED BY HAND
2	DPH 2	7.5	0.012	12"	0.012	0.012	0.012	0.012	
3	DPH 3	7.5	0.012	12"	0.012	0.012	0.012	0.012	
4	DPH 4	7.5	0.012	12"	0.012	0.012	0.012	0.012	
5	DPH 5	7.5	0.012	12"	0.012	0.012	0.012	0.012	
6	DPH 6	7.5	0.012	12"	0.012	0.012	0.012	0.012	
7	DPH 7	7.5	0.012	12"	0.012	0.012	0.012	0.012	AT PANEL DPLA
8	DPH 8	7.5	0.012	12"	0.012	0.012	0.012	0.012	AT PANEL DPLA
9	DPH 9	7.5	0.012	12"	0.012	0.012	0.012	0.012	
10	DPH 10	7.5	0.012	12"	0.012	0.012	0.012	0.012	

PANEL "DPLA"									
NO.	SERIES	STARTED DATE	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	REMARKS
1	DPH 1	7.5	0.012	12"	0.012	0.012	0.012	0.012	
2	DPH 2	7.5	0.012	12"	0.012	0.012	0.012	0.012	
3	DPH 3	7.5	0.012	12"	0.012	0.012	0.012	0.012	
4	DPH 4	7.5	0.012	12"	0.012	0.012	0.012	0.012	
5	DPH 5	7.5	0.012	12"	0.012	0.012	0.012	0.012	
6	DPH 6	7.5	0.012	12"	0.012	0.012	0.012	0.012	
7	DPH 7	7.5	0.012	12"	0.012	0.012	0.012	0.012	
8	DPH 8	7.5	0.012	12"	0.012	0.012	0.012	0.012	
9	DPH 9	7.5	0.012	12"	0.012	0.012	0.012	0.012	
10	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	

PANEL "DPHB"									
NO.	SERIES	STARTED DATE	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	REMARKS
1	DPH 1	7.5	0.012	12"	0.012	0.012	0.012	0.012	VARIABLE SPEED BY HAND
2	DPH 2	7.5	0.012	12"	0.012	0.012	0.012	0.012	
3	DPH 3	7.5	0.012	12"	0.012	0.012	0.012	0.012	
4	DPH 4	7.5	0.012	12"	0.012	0.012	0.012	0.012	
5	DPH 5	7.5	0.012	12"	0.012	0.012	0.012	0.012	
6	DPH 6	7.5	0.012	12"	0.012	0.012	0.012	0.012	
7	DPH 7	7.5	0.012	12"	0.012	0.012	0.012	0.012	AT PANEL DPLA
8	DPH 8	7.5	0.012	12"	0.012	0.012	0.012	0.012	AT PANEL DPLA
9	DPH 9	7.5	0.012	12"	0.012	0.012	0.012	0.012	
10	DPH 10	7.5	0.012	12"	0.012	0.012	0.012	0.012	

PANEL "DPLB"									
NO.	SERIES	STARTED DATE	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	REMARKS
1	DPH 1	7.5	0.012	12"	0.012	0.012	0.012	0.012	
2	DPH 2	7.5	0.012	12"	0.012	0.012	0.012	0.012	
3	DPH 3	7.5	0.012	12"	0.012	0.012	0.012	0.012	
4	DPH 4	7.5	0.012	12"	0.012	0.012	0.012	0.012	
5	DPH 5	7.5	0.012	12"	0.012	0.012	0.012	0.012	
6	DPH 6	7.5	0.012	12"	0.012	0.012	0.012	0.012	
7	DPH 7	7.5	0.012	12"	0.012	0.012	0.012	0.012	
8	DPH 8	7.5	0.012	12"	0.012	0.012	0.012	0.012	
9	DPH 9	7.5	0.012	12"	0.012	0.012	0.012	0.012	
10	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	

PANEL "DPHC"									
NO.	SERIES	STARTED DATE	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	REMARKS
1	DPH 1	7.5	0.012	12"	0.012	0.012	0.012	0.012	VARIABLE SPEED BY HAND
2	DPH 2	7.5	0.012	12"	0.012	0.012	0.012	0.012	
3	DPH 3	7.5	0.012	12"	0.012	0.012	0.012	0.012	
4	DPH 4	7.5	0.012	12"	0.012	0.012	0.012	0.012	
5	DPH 5	7.5	0.012	12"	0.012	0.012	0.012	0.012	
6	DPH 6	7.5	0.012	12"	0.012	0.012	0.012	0.012	
7	DPH 7	7.5	0.012	12"	0.012	0.012	0.012	0.012	
8	DPH 8	7.5	0.012	12"	0.012	0.012	0.012	0.012	
9	DPH 9	7.5	0.012	12"	0.012	0.012	0.012	0.012	
10	DPH 10	7.5	0.012	12"	0.012	0.012	0.012	0.012	

PANEL "DPLB"									
NO.	SERIES	STARTED DATE	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	REMARKS
1	DPH 1	7.5	0.012	12"	0.012	0.012	0.012	0.012	
2	DPH 2	7.5	0.012	12"	0.012	0.012	0.012	0.012	
3	DPH 3	7.5	0.012	12"	0.012	0.012	0.012	0.012	
4	DPH 4	7.5	0.012	12"	0.012	0.012	0.012	0.012	
5	DPH 5	7.5	0.012	12"	0.012	0.012	0.012	0.012	
6	DPH 6	7.5	0.012	12"	0.012	0.012	0.012	0.012	
7	DPH 7	7.5	0.012	12"	0.012	0.012	0.012	0.012	
8	DPH 8	7.5	0.012	12"	0.012	0.012	0.012	0.012	
9	DPH 9	7.5	0.012	12"	0.012	0.012	0.012	0.012	
10	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	

PANEL "DPSL"									
NO.	SERIES	STARTED DATE	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	REMARKS
1	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	
2	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	
3	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	
4	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	
5	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	
6	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	
7	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	
8	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	
9	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	
10	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	

PANEL "DPLB"									
NO.	SERIES	STARTED DATE	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	NO. OF UNITS	REMARKS
1	DPH 1	7.5	0.012	12"	0.012	0.012	0.012	0.012	
2	DPH 2	7.5	0.012	12"	0.012	0.012	0.012	0.012	
3	DPH 3	7.5	0.012	12"	0.012	0.012	0.012	0.012	
4	DPH 4	7.5	0.012	12"	0.012	0.012	0.012	0.012	
5	DPH 5	7.5	0.012	12"	0.012	0.012	0.012	0.012	
6	DPH 6	7.5	0.012	12"	0.012	0.012	0.012	0.012	
7	DPH 7	7.5	0.012	12"	0.012	0.012	0.012	0.012	
8	DPH 8	7.5	0.012	12"	0.012	0.012	0.012	0.012	
9	DPH 9	7.5	0.012	12"	0.012	0.012	0.012	0.012	
10	PANEL "LAST"	7.5	0.012	12"	0.012	0.012	0.012	0.012	

Form Name	SAI
Drawn By	SAI
Checked By	SAI
Name (Last)	SAI
Scale	SAI
Sheet No.	SAI
E-6	

Solar Energy Research Institute (SERI)
1617 Central Expressway
Golden, Colorado 80401

Page 1: Miscellaneous & Systems, Assoc.
Energy Management & Control Systems, Inc.
Page 2: Energy.

Science Applications, Inc.
1710 Goodridge Drive
McLean, Virginia 22101

Zumwalt & Voth, Inc (SAI Subsidiary)
1330 River Bend Dr
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Agricultural Experiment Station TAFS
17360 Coit Road
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Gasper Berger Associates PC (GABA)
714 F. 1st Ave
New York, New York 10011

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Robert E. McInnes Inc. (REMI)
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[illegible]

Item Name <u>SAV</u> Drawn By <u>RT</u> Checked By <u>ML</u> Release Date <u>A: 11-11-81</u> Serial <u> </u>	SAI Original By <u>AS</u> Date Rec'd <u>11/11/81</u>
Sheet No. <u> </u>	14 E-7

sceas

Marketing Agents

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants

Project Management & Systems Analysis
Energy Machine of 88 for the Systems Energy
Project 2. Planning

Science Applications Inc.
1710 Goodridge Drive
McLean, Virginia 22102

Environmental & Weather, Inc. (E&W)
5330 River Bend Dr.
Dallas, Texas 75247

Agricultural & Greenhouse Planning

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Dallas, Texas 75252

Architectural & Structural Design

Georgi Berger Associates, P.C. (GBA)
744 Fifth Ave.
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Environmental Analysis & Distribution System Users

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Box 688 Richardson Texas 75080

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P.O. Box 38645
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Cost Estimating & Construction Planning

Robert E. McPherson, Inc. (REMI)
P.O. Box 38648
Dallas, Texas 75238

ELECTRICAL SYMBOLS

	Lighting outlet (ceiling, wall)
	Fluorescent lighting outlet
	Ceiling light (ceiling, wall)
	5
	5-200 duplex receptacle
	5-200 duplex floor receptacle
	5-200 duplex receptacle 6" above counter or splash
	5-200 duplex 6" receptacle
	Special receptacle as noted or scheduled
	Switch
	3-way switch
	4-way switch
	Switch with other light
	Telephone outlet
	Telephone floor outlet
UH	Unit heater
EW	Electric water cooler
RF	Refrigerator
TH	Thermostat
	Lighting & appliance panel/symbol
	Fire alarm panel or motor control center
	Transformer
	Motor controller
	Photocopy switch
	Substation starter/disconnect
	Junction box
	Motor location
	Manual motor starter w/light fixture
	Circuit indication
	Switching indication
	Circuit being run (10/2 3/4" 12-20A CB) or as noted
	Empty conduit - 3/4" unless noted
	Conduit stay up to equipment
	Fire alarm manual pullstation
	Fire alarm horn & light
	Pullstation with horn & light above
	Fire alarm bell & light
	Pullstation with bell & light above

Message Agency

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants

Project Manager & Systems Analyst:
Energy, Materials & Electrical Systems (ESES)
Power 2, Planning

Science Applications Inc.
1710 Goodridge Drive
Shelton, Virginia 22102

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Dallas, Texas 75247

Agricultural & Greenhouse Planning

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Agricultural Experiment Station (AES)
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Dallas, Texas 75252

Architectural & Structural Design

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New York, New York 10011

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Cost Estimating & Construction Planning

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P.O. Box 38846
Dallas, Texas 75238

ELECTRICAL ONE - LINE DIAGRAM

NO SCALE

Form Name: <u>Z&V</u>	SAI
Drawn By: <u>D.M. 4/1/81</u>	
Checked By: <u>B.M.</u>	Checked By: <u>1/1/81</u>
Issue Date: <u>2-17-81</u>	Issue Date: <u>2/1/81</u>
Scale: _____	
Sheet Title: _____	
E-9	

sceas

Monthly Report

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants:

Project Management & Systems Analysis
Energy, Mechanical & Electrical Systems Design
Phase 2: Design

Science Applications, Inc.
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Distribution System Design

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McCormack Corporation
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Dallas, Texas 75238

Cost Estimating & Construction Planning

Robert E. McPherson, Inc. (REM)
P.O. Box 35645
Dallas, Texas 75238

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Item Name: <u>SAI</u>	SAI
Drawn By: <u>DPE</u>	
Checked By: <u>YH</u>	Checked By: <u>YH</u>
Issue Date: <u>10/1/82</u>	Issue Date: <u>10/1/82</u>
Scale: _____	
Sheet Title: <u>ENERGY SYSTEM BLOCK AND P&ID DIAGRAM</u>	No: <u>E-01</u>

Managing Agents

Solar Energy Research Institute (SERI)
1617 Castle Boulevard
Golden, Colorado 80401

Project Participants

Project Management & Systems Analysis
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Form Name: <u>SAI</u>	SAI
Drawn By: <u>DPF</u>	
Checked By: <u>DPF</u>	Checked By: <u>HSC</u>
Issue Date: <u>2/2/81</u>	Issue Date: <u>3/1/81</u>
Scale: <u>NONE</u>	
Sheet Title: <u>Py ARRAY SCHEMATIC</u>	No. <u>E-02</u>

sceas

Marketing Agency

Sole Energy Research Institute (SERI)
1617 C. Avenue
Golden, Colorado 80401

Project Participants

Truck 1 Management & Systems, Inc.
Energy, Mechanical & Electrical Systems, Utility
Process, Insurance

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Cost Estimating & Construction Planning

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CONTROLLED ENVIRONMENT AGRICULTURE SYSTEM SCIAS

NOTES

1. PROVIDE FOR NINE BRANCH CIRCUITS
2. INSTALL IN ENCLOSURE WITH ALL WIRING PROTECTED FROM ACCESS. CONTROL SWITCHES, BANANA JACKS, AND METER MAY BE INSTALLED IN SEPARATE PANEL BOX IF DESIRED.
3. AWG #12 MAY BE USED IN LIEU OF AWG #10 FOR CONNECTIONS TO SHORTING AND POWER BUSES IF CONDUIT LENGTHS DO NOT EXCEED 500 FEET.

8	SWITCH, DPDT, CENTER OFF	9
1	TERMINAL BLOCK FOR INSULATED CURRENT MONITOR (1000V, 10A, SERIES OR EQUIVALENT)	1
6	100V BANANA JACK, 3/4" O.C., H.P. SWITCH 1014 RE OR EQUIVALENT	1
5	SWITCH, 50 WATT 15A, G.E. 50-140-0311 NEAR OR EQUIVALENT	9
4	SWITCH, 100 WATT 15A, G.E. 50-140-0311 P/AA OR EQUIVALENT	1
1	VOLTMETER, 75V, 0-500 VDC	1
7	RELAY, SPDT, 1000VDC, NON-STANDARD ADAPTATION (24V, 100W, SERIES RELAY)	9
1	DIODE, 100V, 100W, 1N4001 OR EQUIVALENT	10
11	DESCRIPTION	07

Firm Name	SAI
Drawn By	D.P.F.
Checked By	Checked By <i>[Signature]</i>
Issue Date	Issue Date 4.2.1
Scale	NONE
Sheet Title	No
PY BRANCH CIRCUIT SWITCHING	E-03

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

From: Management & Systems Agency
Energy, New Power & Electrical Systems Group
Date: 1990

Science Applications, Inc.
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Dallas Texas 75235

TENTATIVE DRAINAGE LOCATIONS
 FINAL LOCATIONS TO BE PLACED ON
 THE AFTER SOME CONSIDERATION
 MEASUREMENTS AND MAPS

Form Name: <u>SAI</u>	SAI
Drawn By: <u>DPE</u>	
Check In With: <u>2166 Jette</u>	Checked In: <u>11/6</u>
Issue Date: <u>24 Nov 82</u>	Issue Date: <u>1/6/83</u>
Scale: <u>1/8" = 1'</u>	
Sheet Title:	
PS FIELD (AY03)	E-04

Solar Energy Research Institute (SERI) :
1617 Cole Boulevard
Golden, Colorado 80401

From: Management & Systems, April 1972
 From: Management & Systems, April 1972
 From: Management & Systems, April 1972

Zussman & Vothler, Inc. (S.A.) Subsidiary
1330 River Road Dr.
Oxford, Mass. 01547

Texas A&M University
Agricultural Experiment Station (TAES)
17380 Coit Road
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Gargis Burger Associates PC. (212) 691-1111
714 Fifth Ave
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University of Texas at Dallas RU1D
Box 808 Richardson, Texas 75080

McCormack Corporation
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Dallas, Texas 75238

Robert E. McNeel, Inc. (REM)
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Dallas, Texas 75235

SCALE - 1/4" = 1'-0"

CROSS MEMBERS
IN FOUNDATION:
[3" x 5" x 7'-0" LONG (b) - 2 EACH
[3" x 5" x 7'-6" LONG (A) - 2 EACH

5'-0" O.C. N-S
11'-0" O.C. E-W (EACH MODULE,
MODULE TO MODULE COLUMN
SPACING APPROXIMATELY 8'-4" E-W)

$$SCA_1 = 1^{\circ} 51' - 0^{\circ}$$

1. ALL STEEL STRUCTURAL SHAPES ASTM A36 STEEL
2. BOLTS, COLUMNS TO PURLINS & TO CROSS BRACES, 3/8" DIA UNFINISHED ANY STEEL ALLOY
3. BOLTS, PURLINS TO RAFTERS, 1/2" DIA UNFINISHED ANY STEEL ALLOY
4. BOLTS, MODULES TO PURLING & MODULE TO MODULE - 1/8" Ø ALUMINUM BOLT.
5. WEB-TO- WEB RIGID CONNECTIONS OF COLUMNS TO RAFTERS, PLANGES OF RAFTERS FACE IN, FLANGES OF PURLING FACE SOUTH.
6. RAFTERS, PURLING AND COLUMNS ABOVE FOUNDATIONS TO HAVE HIGH QUALITY APPLIED SHOP COATING SPECIFICATIONS TO BE DEVELOPED FIELD TOUCH-UP INCLUDING ABOVE AND STEEL BOLTS, NUTS AND WASHERS AFTER INSTALLATION SHALL BE TO BE REMOVED FROM CHANNEL SECTIONS WHICH ARE TO BE WITHIN FOUNDATIONS.

Form Number: <u>SAI</u>	SAI
Drawn By: <u>DPF</u>	
Checked By: <u>SW S. Myers</u>	(Checked By: <u>SW</u>)
Issue Date: _____	Issue Date: <u>5/12/75</u>
Scale: <u>AS NOTED</u>	
Grade Title: _____	
PV ARRAY STRUCTURAL SUPPORT AND FOUNDATION PRELIMINARY	E-05

sceas

Monday, April 1

State Energy Research Institute (SERI)
1617 Line Boulevard
Golden, Colorado 80401

Project Participants:

Project Management & Systems Analysis
Energy, Mechanical & Electrical Systems (Energy
Physics) - Houston

Science Applications Inc.
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Form Name: <u>C-I</u>	SAI
Drawn By: <u>DPE</u>	
Checked By: <u>[Signature]</u>	Checked By: <u>[Signature]</u>
Issue Date: <u>10/1/81</u>	Issue Date: <u>10/1/81</u>
Issue No: <u>1</u>	Issue No: <u>1</u>
CONTROL AND INSTRUMENTATION SYSTEM BLOCK DIAGRAM	
C-01	

sceas

Network: Alpha

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
Golden, Colorado 80401

Project Participants:

Project Management & Systems Analysis
Energy Management & Electrical Systems Group
Phase 2 - Hardware

Source Applications Inc.
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GROWING COMPARTMENT DISPLAY/MANUAL CONTROL PANEL

GROWING COMPARTMENT LOCAL CONTROL PANEL

NOTES

1. Panels for compartments 1, 2, 3 and 4 as shown.
2. Two least significant digits of CO₂ level set points to be dummy zeros.
3. Provide holes for #10 mounting screws 18 3/8" O.C. horizontally. Standard 618 spacing with 1st row hole 5/32" from top.

Legend

- Alarm. Illuminated emergency action switch. Red lamp or lens.
- Auto/manual selector. Illuminated alternate action or reactor switch. Yellow lamp or lens.
- Control switch and status indicator. Illuminated alternate action or reactor switch. Green lamp or lens.
- Push or lever switch. 2-pole BCD 0 to 9.

Form Name: <u>SAI</u>	SAI
Drawn By: <u>DPF</u>	
Checked By: <u>[Signature]</u>	Checked By: <u>[Signature]</u>
Issue Date: <u>4-92</u>	Issue Date: <u>4-92</u>
Scale: <u>NONE</u>	
Show Title:	
GROWING COMPARTMENT DISPLAY/CONTROL PANEL	C-02

Solar Energy Research Institute S E R I
1617 Cole Boulevard
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Pharm. & Med. J. 1901, 1, 1000.

Science Applications Inc.
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University of Texas at Dallas R110
Box 808 Richardson Texas 75080

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Dallas, Texas 75238

Robert E. McLean Inc. (REM)
PO Box 358-18
Dallas, Texas 75235

Alarm. Illuminated emergency action switch. Red lamp or lens.

Y	Auto/manual selector. Illuminated alternates action or reactor switch. Yellow lamp or lens

Q Control switch and status indicator illuminated alternate action or reactor switch. Green lamp or lens.

thumb or lever wheel switch. 2-pole BCO 0 to 4

481 WATER CIRCULATION PANEL IS IDENTICAL EXCEPT FOR LABEL

Form No.: <u>SAI</u>	SAI
Drawn By: <u>DPF</u>	
Checked By: <u>allegro</u>	Checked By: <u>LSA</u>
Issue Date: <u>2-15-82</u>	Issue Date: <u>2-15-82</u>
Scale: <u>NONE</u>	
Sheet No.	No.
WELL & RING WALL DISPLAY CONTROL PANEL	C-03

Multiple: April

Solar Energy Research Institute SRI
1617 Cook Boulevard
Golden, Colorado 80401

Project Participants:

Project Management & Systems Analysis
Energy Management & Simulation Laboratory
Purdue University

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Control Electronics & Construction Hardware:

Robert E. Munn, Inc. (REM)
P.O. Box 35448
Dallas, Texas 75235

LEGEND:

- Alarm, illuminated momentary action switch, Red lamp or lens
- Auto/manual selector, illuminated alternate action or rocker switch, Yellow lamp or lens
- Control switch and status indicator, illuminated alternate action or rocker switch, Green lamp or lens
- Thumb or lever wheel switch, 2-pole BCD U. L. 9.

Form Name: <u>SAI</u>	SAI
Drawn By: <u>DDF</u>	
Checked By: <u>[Signature]</u>	Checked By: <u>[Signature]</u>
Issue Date: <u>8-27-82</u>	Issue Date: <u>11-1-82</u>
Scale: <u>NONE</u>	
Sheet Title: <u>RESOLAN CDS SYSTEM DISPLAY/CONTROL PANEL</u>	<u>C-04</u>

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Marketing Agents:

Solar Energy Research Institute (SERI)
1617 Cole Boulevard
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Project Participants:

Project Management & Systems Analysis
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Form Name: <u>SAI</u>	SAI
Drawn By: <u>DPE</u>	
Checked By: <u>[Signature]</u>	Checked By: <u>[Signature]</u>
Name: <u>SAI</u>	Name: <u>SAI</u>
Scale: <u>NONE</u>	
Sheet Title: <u>BATTERY DISPLAY/CONTROL PANEL</u>	Sheet Title: <u>C-04-A</u>

sceas

Address: Austin

Solar Energy Research Institute (SERI)
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Energy, Measurement & Instrumental Systems, Denver
Process: Houston

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Form Name: <u>SAI</u>	SAI
Drawn By: <u>DBF</u>	
Checked By: <u>[Signature]</u>	Checked By: <u>[Signature]</u>
Issue Date: <u>1/1/82</u>	Issue Date: <u>1/1/82</u>
Sheet Title: <u>CONTROL AND INSTRUMENTATION SYSTEM - TYPICAL DEVICE CONTROL WIRING</u>	Sheet No: <u>C-05</u>

4/4

NOTE: WIRING SHOWN IS FOR DEMONSTRATION UNIT
NOT IN WIRING COMPARTMENT 1 THIS
TYPICAL OF ALL WIRING FOR DEMONSTRATION
UNIT. WIRING FOR THE ACTUAL SYSTEM
FOR ALL COMPARTMENTS
SEE LAYOUT DIAGRAMS FOR SIGNAL DESIGNATION

Ministry Agency

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Project Participants

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Denver, Colorado

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FUNCTION	QTY	CONFIGURATION
COMPARTMENT AVG. DRY BULB TEMP	4	A
COMPARTMENT AVG. WET BULB TEMP	4	A
COMPARTMENT AVG. SOIL TEMP	4	B
COMPARTMENT AVG. ROOF TEMP	4	B
ROOF WATER FROM TANK	2	C
ROOF WATER FROM HEAT EXCHANGER	2	C
ROOF WATER RETURN	4	C
CONDENSOR OUTLET	4	C
WELL WATER TEMP	2	D
WELL WATER RETURN	2	D
CO ₂ AT HEAT EXCHANGER INLET	1	D

ITEM	DESCRIPTION	QTY	UNIT	PRICE	TOTAL	QTY	UNIT	PRICE	TOTAL	QTY	UNIT	PRICE	TOTAL	QTY	UNIT	PRICE	TOTAL
9	THERMOCOUPLE PROBE, TYPE J, OMEGA HD1 SCRN-100-12	1	EA	1.00	1.00	1	EA	1.00	1.00	1	EA	1.00	1.00	1	EA	1.00	1.00
8	METER, 0-1V (SCALE -30 TO +500V)	1	EA	1.00	1.00	1	EA	1.00	1.00	1	EA	1.00	1.00	1	EA	1.00	1.00
7	THERMOCOUPLE ELECTRONIC READOUT METER, OMEGA EP1-6340	1	EA	1.00	1.00	1	EA	1.00	1.00	1	EA	1.00	1.00	1	EA	1.00	1.00
6	INPUT PORT (11/20 HP3497A OPTION 010)	5	EA	5.00	25.00	5	EA	5.00	25.00	5	EA	5.00	25.00	5	EA	5.00	25.00
5	METER 0-500V (0-500V)	5	EA	5.00	25.00	5	EA	5.00	25.00	5	EA	5.00	25.00	5	EA	5.00	25.00
4	AUXILIARY 0-1V OUTPUT FOR ELECTRONIC READOUT METER	5	EA	5.00	25.00	5	EA	5.00	25.00	5	EA	5.00	25.00	5	EA	5.00	25.00
3	THERMISTOR ELECTRONIC READOUT METER, OMEGA EP2-64010	5	EA	5.00	25.00	5	EA	5.00	25.00	5	EA	5.00	25.00	5	EA	5.00	25.00
2	THERMISTOR PROBE OMEGA OR 970-64007	13	EA	13.00	169.00	13	EA	13.00	169.00	13	EA	13.00	169.00	13	EA	13.00	169.00
1	THERMISTOR, OMEGA OR 970-64007	4	EA	4.00	16.00	4	EA	4.00	16.00	4	EA	4.00	16.00	4	EA	4.00	16.00

Item Name: SAI	SAI
Drawn By: DPE	
Checked By: [Signature]	Checked By: [Signature]
Name Date: [Signature]	Name Date: [Signature]
Scale: N/A	
Name Title: [Signature]	
TEMPERATURE TEMPERATURE	C-06

sceas

Ministry, April

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Project Participants:

Project Management & Systems Analysis
Energy, Materials & Environmental Systems Group
Phase 1, Phase 2

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Form Name: <u>SAI</u>	SAI
Drawn By: <u>DDF</u>	
Checked By: <u>albert</u>	Checked By: <u>PHG</u>
Issue Date: <u>28 Nov 77</u>	Issue Date: <u>11/17/77</u>
Drawn:	
Scale:	
Project File:	
PROJECTORIAL STATION	C-08

McCORMACK CORPORATION

Municipal and industrial water and waste treatment systems
PO Box 38645 Dallas Tx 75238 Telephone (214) 272 5577

rev	date	revision	by	drawn by	date	REVERSE OSMOSIS SKID - SCEASP		
				pete	1-17-82	SERI CONTRACT No. AT-1-9512-B		
				chkd	1/28/82	S&I PROJECT No. 1-151-04-855-XX		
				apvd	3/1/82	drawing number	TE-1520-B02	revision number
				apvd		scale	NONE	sheet of

LEGEND:

- A. 16" DIA DUAL MEDIA FILTER
- B. 16" DIA. CARBON FILTER
- C. (2) 12" DIA. WATER SOFTENER
- D. (2) 5.0 MICRON CARTRIDGE FILTER.
- E. HEX-PO4 FEED SYSTEM
- F. BRINE TANK

SKID No.1

MCCORMACK CORPORATION

Municipal and industrial water and waste treatment systems
PO Box 38645 Dallas Tx 75238 Telephone (214) 272 5577

rev	date	revision	by

drawn by	FETE	date	1-19-82
chkd	WE	date	1/20/82
apvd	HSL (SAI)	date	3/1/82
apvd			

PRE-TREATMENT SKID - SCASBP	
SERI CONTRACT # AT-1-9312-2	
S&I PROJECT NO. 1-151-04-355-XX	
drawing number	TE-1520-B03
scale	NONE
sheet	1 of 1

APPENDICES

64

MCCORMACK CORPORATION

Municipal and industrial water and waste treatment systems
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rev	date	revision	by

drawn by	PETE	date	1-20-82
chkd	WS	date	1/28/82
apvd	HSL(SAI)	date	3/1/82
apvd			

50.8 CM MIXED BED D.I. - SCEASP SERI CONTRACT # AT-1-9512-2 S&I PROJECT NO. 1-151-04-355-XX			
drawing number TE-1520-1004		revision number	
scale	NONE	sheet	of