2. SUMMARY OF PROPOSED WORK

Electronic advancements of recent years have placed a challenge to undergraduate chemistry faculty to incorporate the use of modern chemical instrumentation into the undergraduate laboratories. To meet this challenge, undergraduate faculty members need to understand better the use and capabilities of modern instrumentation. This proposal addresses this need to update two-year college faculty in the area of chemical instrumentation. This project is a two-year effort which continues a successful Instrumentation Workshop currently funded by NSF. We have made modifications to the content of some of the workshops to respond to the changing needs of 2-year college chemistry faculty. The participant evaluations of the previous project were highly favorable and the applications to attend for the first and second sets of workshops greatly outnumbered the capacity of workshops offered. The existing coalition consists of East Coast (Northern Virginia Community College and George Mason University, Midwest (Sinclair Community College and the University of Dayton), and West Coast (Shoreline Community College and Western Washington University). One-week workshops will be offered at each region at separate times during each summer for two years. Instruction will focus on undergraduate general and organic chemistry, introduction to instrumental analysis and associate degree chemical technology course applications. The goal of this project is to train a total of 108 chemistry faculty (54 per year) from two-year colleges across the United States on the theory, techniques, and laboratory use of state-of-the-art chemical instrumentation. There will be an emphasis on incorporating the use of computers and modern instrumentation into the applications of environmental chemistry. Two-year college chemistry faculty will select instruction in the following areas: Fourier-transform infrared, gas chromatography/mass spectroscopies, vapor phase and high performance liquid chromatography, computerized data acquisition and treatment, multimedia approaches to chemical education, and environmental chemistry.

INSTRUMENTATION WORKSHOPS
FOR TWO-YEAR COLLEGE CHEMISTRY FACULTY
3. TABLE OF CONTENTS

4. NARRATIVE

A. INTRODUCTION / GOAL AND OBJECTIVES

This proposal requests a continuation of two current successful NSF Undergraduate Faculty Enhancement projects (Summers of 1992 and 1993; Summers of 1995 and 1996). The response from the faculty participants has been so favorable over the first two years that it was expanded from one workshop site to three; the workshop content has increased; and the workshops offered at different times during the summer. This new format has proven to be so successful that the workshops have not yet satisfied a large need by two-year college chemistry faculty.

This proposal outlines a third cooperative venture of the chemistry departments at six institutions (1) Sinclair Community College (Dayton, OH); (2) Northern Virginia Community College (Annandale, VA); (3) Shoreline Community College (Seattle, WA); (4) the University of Dayton (Dayton, OH); (5) George Mason University (Fairfax, VA); (6) the Western Washington University (Bellingham, WA); in cooperation with the Committee on Chemistry in the Two-Year College (COCTYC). This coalition will sponsor a comprehensive series of Instrumentation Institutes for two-year college chemistry faculty. Scheduled for the summers of 1998 and 1999 in Dayton, OH; Fairfax, VA; and Bellingham, WA, the project will have:

- Each Instrumentation Institute site directed by a two-year college chemistry faculty member with an Assistant Director from the four-year college which hosts the Instrumentation Institute.
- Instrumentation Institute Directors responsible for all activities related to the two-year college chemistry participants including recruitment, communication with two-year participants and evaluations.
- Instrumentation Institute Assistant Directors responsible for providing the services required from the four-year colleges to produce a week-long Instrument Institute including housing, teaching faculty and instructional support.
- The Project Director centrally responsible for recruitment, evaluation, and related activities.
- Curriculum of workshops as well as special and related activities coordinated by the Director and Assistant Director at each Instrumentation Institute site.

Table I summarizes the project organization and provides short job descriptions of the project team.

Table I: Project Organization

<table>
<tr><td colspan="3">Principal Director
Richard F. Jones, Ph.D.
Sinclair Community College
Supervise the project, responsible for budget, recruitment and selection of participants, quality control of each workshop center, evaluations and report to NSF. Liaison to COCTYC, communications with COCTYC, use of membership lists, regional meetings and publications.</td></tr>
<tr><td>East Coast Director
Martha W. Sellers, Ph.D.
Northern Virginia Community College
Supervise the East Coast Center, be responsible for quality of program activities.</td><td>Midwest Director
Richard F. Jones, Ph.D.
Sinclair Community College
Supervise the Midwest Center, be responsible for quality of program activities.</td><td>West Coast Director
Clarita C. Bhat, Ph.D.
Shoreline Community College
Supervise the West Coast Center, be responsible for quality of program activities.</td></tr>
<tr><td>Assistant Director
Wayne Stalick, Ph.D.
George Mason University
Coordinate the four-year college activities, select and supervise workshop faculty, housing and board arrangements.</td><td>Assistant Director
R. Gerald Keil, Ph.D.
University of Dayton
Coordinate the four-year college activities, select and supervise workshop faculty, housing and board arrangements.</td><td>Assistant Director
Mark Wicholas, Ph.D.
Western Washington University
Coordinate the four-year college activities, select and supervise workshop faculty, housing and board arrangements.</td></tr>
</table>

B. RESULTS FROM PRIOR NSF SUPPORT

As indicated above, this project has offered Instrumentation Institutes for two cycles of NSF funding (see appendix A). Table II provides a summary of the projects.

TABLE II: Summary of Prior Projects

	Summers of 1992 & 1993	Summer of 1995 & 1996
Workshop Sites	• Dayton, OH	• Fairfax, VA • Dayton, OH • Bellingham, WA
Format	Two-week Institutes	One-week Institutes
Number of Applicants	180	179 (1995); 85 (1996)
Number of Participants	63 (1992+1993)	64 (1995); 60 (1996)
Percent Women Participants	39% (1992) 34% (1993)	44% (1995) (30% 1996)
Percent Minority Participants	13% (1992) 6% (1993)	3% (1995) (18% 1996)
Partners	1. Sinclair Community College 2. University of Dayton 3. In cooperation with Committee on Chemistry in the Two-Year College	1. Sinclair Community College 2. Northern Virginia Community College 3. Shoreline Community College 4. University of Dayton 5. George Mason University 6. Western Washington University 7. In cooperation with the Committee on Chemistry in the Two-Year College

The two-year college participants were very pleased with the instruction they received (Table III).

Table III. Exit Evaluation of Participants

	Summer 1992				Summer 1993				Summer 1995				Summer 1996			
	E*	G*	F*	P*	E	G	F	P	E	G	F	P	E	G	F	P
Workshop	30	11	3	0+	38	10	0	0+	58	6	0	0	44	4	0	0
Overall Organization	21	6	0	0	20	1	0	1	55	9	0	0	45	6	0	0
Program Format	13	11	2	0	20	10	0	0	54	9	0	0	47	4	0	0

* E = Excellent; G = Good; F = Fair; P = Poor
+ two workshops were offered each summer

A follow-up survey taken several months after the Instrumentation shows a significant impact upon the home college chemistry curriculum (Table IV).

Table IV. Participant Activities Resulting From Workshops

Activity	Summer 1992 (16 responses)	Summer 1993 (24 responses)	Summer 1995 (37 responses)	Summer 1996 N/A
Incorporate a new lab experiment into curriculum	88%	71%	57%	
Started using a new instrument	88%	42%	16%	
Requested a new instrument through college budget process	38%	33%	27%	
Wrote a proposal	44%	12%	35%	
Sought Industrial donation	38%	38%	0%	
Added the use of simulation software to your curriculum	N/A	N/A	35%	

Based upon faculty surveys the Institutes have been modified. Both participants and teaching faculty felt the two-week format was too long and fatigue became a factor. In addition, most two-year college faculty must teach during the summer and four-year university faculty have competing research requirements during the summer. So the one-week format was adopted. Additional topics were also added based on feedback.

The applications for the 1997 Summer Workshops show a preference for computer related topics and a weaker interest in NMR and AA. The shift of various NMR instrument vendors from inexpensive instruments to expensive instruments will most likely make most two-year colleges shift from acquiring NMRs to teaching the techniques with simulation software. Also, there is a resurgence in environmental science and hazardous materials management programs.

This proposal builds upon the experience and evaluations of the previous NSF projects and has the following characteristics:

- Three, one-week instrument workshops will be offered at different times during the summer to allow for two-year college chemistry faculty to teach during the summer and still attend one workshop without loss of pay.
- The East Coast, Midwest, and West Coast Centers will allow for more geographic accessibility and ease of travel. This will reduce the need for travel stipends.
- The three-site format will allow for greater flexibility in the instrumental methods offered and permits greater numbers of two-year college faculty to attend.
- The one-week format overcomes the fatigue factor and allows four-year university faculty to accomplish their summer research agenda.
- Two new workshops to respond to changing needs of two-year college chemistry faculty:
    - Multimedia Approaches to Chemical Education
    - Environmental Chemistry Instrumentation Workshop

This program will retain the following features from the first two grants:

- **A National Scope**--Chemistry faculty will be recruited from two-year colleges from all regions across the United States.
- **Involvement of Experts**--Instruction will be provided by Institute faculty from the Chemistry Departments at the University of Dayton, George Mason University, and Western Washington University.
- **Opportunities for Professional Growth**--This program is designed to improve the knowledge of two-year college chemistry faculty in the areas of the theory, techniques, and laboratory uses of chemical instrumentation.
- **Involvement of Women and Minority Chemistry Faculty**--Special efforts will be made specifically to target women and minority chemistry faculty at two-year colleges will be made.

GOAL AND OBJECTIVES

The goal of this project is to train a total of 108 chemistry faculty (54 per year) from two-year colleges across the United States on the theory, techniques, and laboratory use of state-of-the-art chemical instrumentation. Specific objectives are:

1. To recruit 54 chemistry faculty per year from two-year colleges across the United States (for a total of 108 faculty) to obtain a regional balance.

2. To assure that at least 40 percent of the participants will be women and minority chemistry faculty.

3. To conduct three sessions of a one-week summer Instrument Institute during the Summers of 1998 and 1999 in Dayton, OH; Fairfax, VA; and Bellingham, WA.

4. To increase the number and success rate of NSF Instrumentation and Laboratory Improvement grant proposals submitted by participating faculty.

5. To improve the knowledge of two-year college chemistry faculty in the area of the theory, techniques, and laboratory uses of chemical instrumentation.

C. TOPICS TO BE COVERED/SUITABILITY OF TOPICS

In recent years, advances in electronic design have greatly influenced chemical instrumentation. Not only have laboratory instruments become more sophisticated and easy to use, they have also become more available and widely used in research and industry. Today, industry relies heavily on instrumental analysis for both compound identification and quantitative analysis. Sophisticated instruments, once available only to research-oriented graduate programs at universities, are now finding their way into the undergraduate laboratories at two-year colleges.

Chemistry faculty at these teaching institutions recognize the benefit to students of incorporating modern chemical instrumentation into their laboratory programs. However, to maximize this benefit, it is essential that faculty be knowledgeable and skilled in both the theory and use of modern instruments such as atomic absorption/flame emission spectrophotometers, Fourier-transform infrared spectroscopy, vapor phase chromatography, high performance liquid chromatography, gas chromatography/mass spectroscopy, computer data acquisition stations and their applications in environmental applications. Chemical instrumentation workshops have been quite popular at Committee on Chemistry in the Two-Year College (COCTYC) conferences over the past several years. Faculty are asking for instruction focused on teaching instruments used in undergraduate organic chemistry, introduction to instrumental analysis, and associate degree chemical technology courses.

The COCTYC reported on a survey of its membership in 1991 [(1)]. While 39% of two-year college chemistry faculty have a Doctorate and 56% have a Master's Degree, the typical faculty member received his/her degree 10 to 15 years ago. Heavy teaching loads make it difficult for these faculty member to keep current with developments in chemistry. In addition, many two-year college chemistry faculty must teach during most of the summer.

Two-year colleges constitute a significant segment of, and make a major contribution to, undergraduate science education in the United States. The magnitude of the contributions is reflected in the following facts:

FACT #1 Two-year colleges enroll 41% of all undergraduate credit chemistry students, and more than 50% of all minority students [(2)].

FACT #2 53% of all first-time college students begin their education at a two-year college [(3)].

FACT #3 Minority students represent only 10% of enrollments at four-year institutions yet 55% of all Hispanic and 43% of all African-American students attend two-year colleges [(4)].

FACT #4 53% of all community college students are women [(5)].

FACT #5 Up to 50% of community college students transfer to four-year universities [(6)].

Clearly, enhancing the knowledge and skills of two-year college faculty improves the fundamental science education of women and minority students. Improving the fundamental science education of women and minority students increases the likelihood they will become future scientists, engineers, and technicians. In addition to teaching students who transfer to four-year programs, many two-year colleges prepare students for employment as Associate Degree Chemical and Allied Health Laboratory Technicians in industry and government.

The American Chemical Society, in its publication ***Guidelines for Chemistry and Chemical Technology Programs in Two-Year Colleges*** [(7)], makes the following recommendations:

S26 "Laboratory work gives students hands-on experience and an opportunity to acquire competence and self-confidence in the use and understanding of modern laboratory instruments **AT A LEVEL EQUIVALENT TO** that in the major transfer institutions." Included in the list of instrumentation are: atomic absorption/flame emission, Fourier-transform infrared spectroscopy, vapor phase chromatography, high performance liquid chromatography, nuclear magnetic resonance spectroscopy, gas chromatography, mass spectroscopy, and computer data acquisition stations.

S34 "Laboratory experience in the chemical technology core curriculum reflects the career orientation of the program in that it helps students develop a wide range of laboratory skills, gives them hands-on knowledge of chemistry using state-of-the-art instrumentation and equipment, and fosters competence and self-confidence, enabling them to: . . . understand and use up-to-date instruments, particularly NMR, IR, FTIR . . . ."

The National Science Foundation has recently recognized the contributions of two-year colleges to science education by opening several programs to proposals from these institutions. In particular, the Instrumentation and Laboratory Improvement (ILI) program has helped two-year colleges to purchase chemical instrumentation. Given the critical economic problems in most states, public two-year college capital equipment budgets often do not allow the purchase of such expensive items. Thus the ILI program is very valuable. However, chemistry faculty in many two-year colleges often are novices in the process of writing grant proposals and need training in this area. A session on grant writing will be included in the Instrumentation Institutes.

As a result of the economic conditions in most states, two-year college faculty at state-supported institutions have seen their travel and faculty development funds either frozen at current levels or even reduced, thus preventing faculty from acquiring needed skill enhancements. Tuition and living expenses are included in this proposal budget to encourage participation.

Clearly National Science Foundation funding is vital to the success of these Summer Instrumentation Institutes. During the summer of 1994, between the first and second cycle of NSF funding for this project, an Institute was developed, scheduled, and marketed. Yet only one faculty member applied due in large part to the high cost. Once NSF funding was obtained, 180 faculty applied each year for the 60 openings for the 1992

and 1993 Summers; 106 faculty applied for the 1995 summer, 73 for the 1996 Summer, and 74 have applied for 36 openings for the 1997 Summer Workshops.

The workshop contents are modified annually to respond to changing needs of two-year college chemistry faculty. The NMR workshop has been deleted because the availability of appropriately-priced instruments is decreasing and replaced it with a "Multimedia" approach to chemical education which will include instrument simulation software as well as data analysis using spreadsheets, presentation software and networking. Also a workshop was assessed focusing on the instrumentation commonly used in environmental chemistry.

The Committee on Chemistry in the Two-Year College (COCTYC), a committee of the Division of Chemical Education of the American Chemical Society, consists of approximately ten members (elected annually with staggered terms) divided among four regions of the United States. (See letter of support in Appendix B.) The committee annually conducts four Two-Year College Chemistry Conferences ($2YC_3$) at various host institutions throughout the United States. In addition regional meetings are held in the Eastern, Midwestern, Southern, and Western areas each year. As of December 1996, $2YC_3$ had over 700 members. Each member all two-year colleges receive the organization's ***$2YC_3$ Newsletter***, a publication of the American Chemical Society Office of Two-Year College Chemistry. It is through these conferences and publications that advertisements of various sponsored activities reach all two-year college chemistry faculty members.

D. INTENDED AUDIENCE/RECRUITMENT METHODS/SELECTION METHODS

The intended audience for the Chemistry Instrumentation Institute is two-year college tenure track chemistry faculty across the United States. Special efforts will be made to attract women and minority faculty. Publicity for the Institute will occur through a multi-faceted approach. First, the Director will include an article and announcement in

the ***COCTYC's Newsletter*** (mailed four times each year to approximately 700 members and 1350 colleges). Second, announcements also will be placed in the ***DIVCHEM Newsletter***, ***The Journal of Chemical Education***, and through other newsletters and publications. Third, brochures will be distributed to chemistry departments at all two-year colleges (approximately 1,350) in the nation. Finally, the Director will mail a personal letter and brochures to all women and minority faculty in two-year college chemistry departments. (These names were obtained recently through a survey conducted by COCTYC of all two-year college chemistry departments.)

A maximum of 54 two-year college chemistry faculty members will be selected each summer to participate (18 at East Coast Center; 18 at the Midwest Center; 18 at the West Coast Center) for a total of 108 faculty over two years. To be selected, a faculty member should:

1. Have at least three years of experience in two-year college chemistry instruction.
2. Have teaching assignments primarily in the freshmen general chemistry or sophomore courses offered at their college.
3. Have some experience in using chemical instrumentation.
4. Hold at least a Masters Degree in Chemistry or a closely-related field.

On the application materials, faculty will indicate their preference for training on one of seven types of instrumentation groups (1. Computer Interfacing, 2. Computer Modeling, 3. Multimedia Approaches to Chemical Education, 4. Environmental Chemistry, 5. Chromatography (GC, GC/MS, GC/HPLC) and 6. FTIR). They will also indicate their site preference (East Coast, Midwest, West Coast).

Interested participants will be asked to return their application form to the Principal Director by mid-February of each year. The Director will mail copies of each application to the selection committee with instructions to rank, in numerical order, the

top 40 applicants and return this to the Director. The selection committee will be made up of the Director, two Assistant Directors, and a member of COCTYC. The Director will compile these lists to find the 54 highest ranking applicants. Selection of participants will be based on: (1) applicant experience, (2) geographic distribution, (3) size and organization of institutions, and (4) numbers of women and minority faculty.

Twelve alternate faculty will be chosen in case some of the selected applicants are unable to participate. Selected participants and alternates will be notified of their status by April 1 of each year.

The notification sent to participants will indicate in which of the instrumentation groups they will receive training during the Institute as well as a list of other participants in their instrumentation group. Those accepted for participation will be expected to review the basic theories pertaining to their chosen instruments. The appropriate materials will be sent to participants prior to the Institute.

E. PLAN OF OPERATION

This project will consist of three, one-week Instrumentation Institutes conducted during different weeks of the summer at an East Coast Center, a Midwest Center and a West Coast Center. Selection of the workshop participants, the number of workshop hours presented, the workshop titles and formats, and evaluations will be national but each regional center will control the curriculum. Table V lists each regional site, the dates, the instrumental workshops offered, and the instructors by instrument at each site.

TABLE V

OUTLINE OF INSTRUMENT WORKSHOPS--SUMMER 1998, 1999

East Coast Center	Midwest Center	West Coast Center
Site: George Mason University	**Site:** University of Dayton	**Site:** Western Washington University
City: Fairfax, VA	**City:** Dayton, OH	**City**: Bellingham, WA
Participants: 18 Faculty	**Participants:** 18 Faculty	**Participants:** 18 Faculty
Date: early June, 1998, 1999	**Date:** early July, 1998, 1999	**Date:** middle August, 1998, 1999
Chromatography Gregory Foster	**Environmental Chemistry** David Johnson	**PC Interfacing** Don King
FTIR Wayne Stalick	**Computer Interfacing** Robert G. Keil	**PC - Software** Donald Pavia
PC - Software Stephen L. Davis	**Computer Modeling of Molecules** James F. O'Brien	**Environmental Chemistry** Devon Cancilla

Institute Faculty are full-time, tenure track chemistry faculty from George Mason University, the University of Dayton, and Western Washington University. Qualifications of Institute Faculty include:

1. Having done original research on the instrument within the past two years.
2. Having extensive experience on entry level instruments that would be used by two-year colleges.
3. Understanding of the educational objectives of lower division chemistry courses that are taught in community colleges.

The lecture, demonstration, and hands-on sessions will consist of proper techniques for calibration, standardization, maintenance selection/purchasing, use of various components of the instrument, and application of the instrument to various types of analysis that have direct classroom application. At the close of these training sessions, participants will be able to:

1. Select the most appropriate instrument for a given type of analysis.
2. Properly prepare samples for analysis.
3. Optimize instrument parameters to obtain maximum output of the instrument.
4. Determine sample interferences and how to minimize them.

5. Prepare necessary calibration curves.

6. Indirectly determine the concentration of a sample component.

7. Evaluate maintenance contracts and decide if they are essential based upon departmental and institutional considerations.

WORKSHOP DESCRIPTIONS

George Mason University

- ***PC Software & Chemistry*** - Faculty explore the use of PC software to supplement and enhance course work in chemistry and survey the various types of tools available, including spreadsheets, presentation graphics, molecular modeling and drawing, simulations and the internet. They become familiar with the capabilities of such tools through tutorials and extensive hands-on use in typical, chemistry-related applications. *Faculty: Stephen L. Davis, Ph.D.*

- ***Chromatography (GC, GC/MS, and HPLC)*** - Experience high-resolution GC and GC/MS separations, and normal-phase, reverse-phase and steric exclusion HPLC. Topics include basic theory of chromatography, GC and HPLC applications, and GC/MS operations. Hands-on practice with GC, GC/MS and HPLC instrumentation in qualitative and quantitative analysis will be emphasized. *Faculty: Gregory Foster, Ph.D.*

- ***Infrared (FT-IR)*** - The basic principles of FT-IR are covered with discussion on the instrumentation, application and advantages over dispersive IR. Faculty obtain extensive spectrometer practice with hand-on practice in qualitative analysis of organic compounds and learn about the computerized data manipulations and search routines available. *Faculty: Wayne Stalick, Ph.D.*

University of Dayton

- ***Computer Interface Workshop*** - Almost every Chemistry Laboratory now involves the use of computers for acquisition of experimental data.. This workshop will provide a hands-on environment toward understanding the integration and interfacing of computers in the instructional chemistry laboratory which will be beneficial to your courses. We will use a commercially available interface (eg., LabView) The efficiency of the data acquisition is so good that laboratory instructional paradigm is now shifted to allow free inquiry in the form of 'what if' questions by the student. Most experiments will be those typical of a general chemistry program, and participants will be encouraged to develop their own project and share (report) the outcome to the entire workshop. *Faculty: Robert G. Keil, Ph.D.*

- ***Computer Modeling of Molecules*** - Every Chemistry course in the curriculum can profit from the use of appropriate computer software. This workshop will provide an opportunity to develop or enhance computer skills that will be applicable to your course presentations. Using the modeling package PC Model, we will do some introductory work, a few more advanced calculations, and then move on to a project of your choice; or a project will be suggested. We will start with semi-empirical calculations, look at the fragment basis approach, and wind up with ab initio calculations. Participants can choose to do a project involving any molecule(s) of interest. Each participant will present a report on one of the projects to the entire workshop. This presentation can be based on molecular modeling or molecular orbital calculations. All will receive copies of the materials generated in the various projects. *Faculty: James F. O'Brien, Ph.D.*

- ***Environmental Chemistry*** - This workshop will be based on metals determination in environmental samples. Participants will gain experience with sampling statistics and sample preparation, including wet and dry ashing techniques and extraction methods, and instrumental methods used in modern environmental analysis. The majority of the workshop will involve a single metal, lead in a variety of sample matrices. The techniques will include simple qualitative determinations of lead in paint; determination of lead in soil samples using flame atomic absorption, anodic stripping voltammetry and calorimetric techniques involving extraction; and lead in ground water and drinking water samples using graphite furnace atomic absorption methods. Samples will come from various sources which will include several locations where lead contamination is a know problem. Data analysis methods based upon sampling statistics and the natural distribution of metals in the environment will also be discussed. *Faculty: David W. Johnson, Ph.D.*

Western Washington University

- ***NSF Computer Interface Workshop*** - The workshop focuses on integration of computers into chemistry laboratory instruction using a commercially available interface (LabWorks). The easy-to-use integrated software/hardware package permits faculty to design experiments, rapidly collect experimental data, and use a spreadsheet to look for generalizations and mathematical relationships. No programming experience is necessary. Experiments are drawn from the freshman chemistry program, although faculty are encouraged to develop experiments for the course they teach. *Faculty: Don M. King, Ph.D.*

- ***Environmental Chemistry*** - This workshop takes a problem-based approach to the identification of environmental contaminants and develops the methodology needed for integrating appropriate environmental experiments in the general chemistry curriculum. Participants will be provided with data and information from an "environmental incident" involving a chemically contaminated site. Using actual environmental samples, participants will develop strategies necessary to define the extent of contamination and will propose a response strategy based upon their

findings. Emphasis will be placed upon the development of appropriate methods using GC, GC/MS and LC systems. *Faculty: Devon Cancilla, Ph.D.*

- ***Use of Computers in Chemistry*** - Chemistry software is the emphasis of this workshop. Faculty use molecular modeling software to calculate molecular geometry and properties, and to display molecules and orbitals. SPARTAN, HyperChem and Alchemy III is available in a networked lab with 5 SGI and 21 IBM-486 computers. Other chemistry tools such as Excel, Isis Draw, Origin-3D, NMR processing and simulation, and a wide variety of instructional and tutorial software is available. Laser disc, CD-ROM, and software materials are available in a network- and internet-connected, multi-media classroom adjacent to the computer lab. *Faculty: Donald Pavia, Ph.D.*

Prior to arrival at the workshops, the workshop faculty will contact each of the two-year college chemistry faculty assigned to the workshop to determine the background level of the two-year faculty, any specific interests of the two-year faculty, and to assign background material for the two-year faculty member to review before arrival. Each workshop will consist of thirty-six hours of both theoretical and hands-on experience with each instrument. Each workshop will be limited to six, two-year college faculty participants and each workshop will provide a minimum of three instruments per workshop or provide one computer per participant. (See Table VI proposed weekly schedule on the next page.)

Within the parameters given above, each regional center will have autonomy to conduct the workshops and optimize the special and unique aspects of each center. Each center will select its faculty, arrange for room and board, and will provide for any special group activities that will enhance the institute's experience and sense of community.

The Principal Director will attend all workshops for the three-year program and assist in conducting NSF ILI proposal writing sessions. An Instrumentation Institute Newsletter, written by the Principal Director, will be mailed to each participant to encourage the exchange of ideas among the participants from various sites and years. The newsletter will consist primarily of names and addresses, news of progress made in introducing instruments into the curriculum, and finally news about proposals written and

status of acquiring new instrumentation. The project timeline following the weekly schedule.

Table VI: Daily Schedule of Instrumentation Institute

Day	Morning	Afternoon	Evening
Sunday	Travel	Travel	Welcome Banquet
Monday	Introduction, logistics, etc.	Instrumentation Workshops	Open Laboratory
Tuesday	Instrumentation Workshops	Instrumentation Workshops	Open Laboratory
Wednesday	Instrumentation Workshops	Instrumentation Workshops	NSF ILI Proposal Writing Workshop
Thursday	Instrumentation Workshops	Instrumentation Workshops	Open Laboratory
Friday	Instrumentation Workshops	Instrumentation Workshops	Concluding Banquet, Debriefing
Saturday	Travel	Travel	Travel

Insert Project Timeline Here.

F. EVALUATION PLAN

On the last day of each Instrumentation Workshop each participant will complete an evaluation form rating the workshop they attended (see Appendix C). These evaluations will be compiled by each Instrumentation Institute site and combined for a comprehensive look at all sites. Approximately one month after each of the workshops are completed, the Director, Assistant Director, and teaching faculty will meet to evaluate the Institute. The results of these evaluations will be shared with other sites. Adjustments will be made to improve the upcoming institutes based upon these results.

Within two months of the end of the last summer sessions, the Project Director, two Site Directors, and three Assistant Directors will meet to evaluate the summer institutes and make plans for the next years program. After approximately six months to one year, follow-up evaluations will be conducted by mail by the Principal Director (see Appendix D).

Further monitoring and evaluations will be made as deemed appropriate by the COCTYC through receiving a Director's report at each regional COCTYC meeting and discussing the outcomes of the prior workshops. This program will become an agenda item for the COCTYC meetings held at each conference. The chair will include information on the success of the project in the COCTYC report to the Division of Chemical Education.

F. QUALITY OF KEY PERSONNEL

This project will be administered by individuals with considerable teaching experience and knowledge of chemical instrumentation. (Biographical sketches are attached following the narrative.) Their roles in the project include the following:

Principal Director and Midwest Center Director: Richard F. Jones, Ph.D.

The Director, Dr. Richard F. Jones, was the Principal Director of the two previous NSF Instrumentation Workshop Program Grants. He is the 1997 “National Catalyst Award” recipient and the 1992 "Catalyst Award" Midwest Regional Award recipient

from the Chemical Manufacturers Association. He received special recognition from the 121st General Assembly of the State of Ohio in December of 1995. Dr. Jones finished his second, three-year term as membership chairperson of the Committee on Chemistry in the Two-Year College and is Chair-Elect of COCTYC. He will be on the Executive Board of COCTYC during the duration of this grant. Dr. Jones has been at Sinclair Community College for 18 years. He is currently Chairperson of the Chemistry Department at Sinclair Community College. Dr. Jones has published 11 papers and has given many papers at regional, national, and international conferences. He chaired the 94th $2YC_3$ Conference in 1986. Dr. Jones earned his Ph.D. in Chemistry from Purdue University.

East Coast Center Director, Martha W. Sellers, Ph.D.

Martha W. Sellers has been a faculty member at Northern Virginia Community College (Annandale, VA) since 1971 with major responsibility in the science major general chemistry sequence which she has coordinated for the past seven years. She also served as the chemistry cluster chairperson from 1987 to 1991. In 1980 Dr. Sellers, as co-director of an NSF Curriculum Development Grant, was responsible for the development and validation of a pre-enrollment chemistry placement test that, upon implementation, significantly increased the success ration of students in chemistry courses. Dr. Sellers was a principle investigator for a three-year U.S. Department of Education FIPSE (Fund for the Improvement of Postsecondary Education) faculty development grant promoting scientific literacy among non-science community college faculty. In August, 1994, she undertook the development of an engineering major chemistry course under the auspices of a Sloan Foundation Grant to the Extended Learning Institute of the College. She created an engineering degree offered entirely through distance education modules but which must retain the rigor and integrity of existing courses. Dr. Sellers earned her Ph.D. at the Catholic University of America

(Washington, D.C.) with a dissertation topic of "Mossbauer Spectroscopy of Some Complexes of Ferrihemeundecapeptide."

West Coast Center Director, Clarita C. Bhat, Ph.D.

Dr. Bhat is Chemistry Professor at Shoreline Community College in Seattle, WA. She earned her Ph.D. in Organic Chemistry with biochemistry as a minor from Georgetown University specializing in Carbohydrates and Nucleosides. Her dissertation, entitled "Synthesis of Anomeric Glycosides, and Pyrimidine Nucleosides of 2-Deoxy-D-allose in the Furanoid Form," concerned the formation of anomeric glycosides in the furanoid form of a 2-deoxy-*ribo*-D-hexose and their nucleosides. Later, from 1967 to 1971, she was at Gulf South Research Institute (GSRI) in Louisiana managing the custom chemicals department synthesizing rare organic chemicals including carbohydrates, deoxy sugars, and nucleosides. Her work at GSRI also involved the analysis and characterization of herbicides and pesticides in soil, plants, and feed mixtures using GLC, TLC, NMR, UV, and MS. She has been at Shoreline Community College since 1973 and also at the University of Washington as an Auxiliary Faculty teaching undergraduate Organic Chemistry courses. She has been studying the kinetics of Liver Alcohol Dehydrogenase on various substrates together with the enzymatic transformation of retinoids with Dr. U. Pocker at the University of Washington as a visiting scholar during the summer recess. Dr. Bhat was chairperson of the Puget Sound Section of the American Chemical Society in 1993. She is program chair of the up-coming 136th $2YC_3$ Conference in Seattle in the late spring of 1996.

East Coast Center Assistant Director and Institute Faculty Member, Wayne M. Stalick, Ph.D.

Dr. Stalick is a professor of chemistry at George Mason University. He earned his Ph.D. in chemistry from Northwestern University, specializing in catalytic organic chemistry. His dissertation, entitled "Base-Catalyzed Addition Reactions of 4-Alkylpyridines in Isoprene and Related Studies," concerned examining orientation and

rates of reactions catalyzed by metallic sodium and potassium followed by the spectroscopic identification of the products formed. He did his postdoctoral work at the Ohio State University with Dr. Mel Newman on a synthesis methods project which involved rigorous spectroscopic interpretation of the products formed. His career at George Mason University started in 1972 and one of his first projects was to write and implement the first NMR experiment that was taught in the organic laboratory. Since that time, he has maintained a good balance between teaching and research. His teaching spans the range from the non-majors organic/biochemistry course through the majors organic sequence and to the graduate course in synthetic and mechanistic organic chemistry. Dr. Stalick's research has resulted in 31 publications including a book "Base-Catalyzed Reactions of Hydrocarbons," co-authored with Dr. Herman Pine, a laboratory manual used in organic laboratories, two book chapters, and 27 articles. Last year, he was a co-PI on a proposal which won a $100,000 NSF-ILI grant for the purchase, with matching funds, of a 300 MHZ NMR for George Mason University. Dr. Stalick has kept abreast of instrumental developments by periodically working at the Naval Research Laboratory; on a sabbatical leave in 1985-86 and as an ASEE-NAVY Fellow during the summers of 1986, 1987, 1991, and 1994.

Teaching Faculty at the East Coast Center

- **Stephen L.Davis, Ph.D.**, Associate Professor, theoretical chemist. He is a computational chemist with extensive experience in programming and in the use of microcomputer applications in chemistry. He has developed instructional software for the PC for use in undergraduate laboratories.
- **Gregory D. Foster, Ph.D**., Assistant Professor, analytic and environmental chemist. He teaches the instrumental laboratory course which introduced GC/HPLC to undergraduate students. He also has 13 years of research experience in the use of these techniques in the analysis of parts per trillion concentrations of organic substances in environmental samples.
- **Wayne Stalick, Ph.D.,** (See above.)

Midwest Center Assistant Director and Institute Faculty Member: R. Gerald Keil, Ph.D.

Jerry Keil is a Professor of Chemistry and Associate Dean of the College of Arts & Sciences at the University of Dayton. Upon completing his Ph.D. in physical chemistry at Temple University in 1967, he joined the research staff at the E.I. duPont de Nemours & Co., in Wilmington, DE. In 1969 he joined the chemistry faculty at the University of Dayton and has remained there except for brief periods of sabbatical leave. His administrative experience includes department chairperson (1988-1991) and Associate Dean (1991-1997). His teaching interests include general, analytical and physical. A particular interest is electrochemical methods which is the focus of his research activities. His research is centered upon energy conversion, electroanalytical methods, computer simulations of reaction mechanisms and surface spectroscopy, from which 19 technical publications have resulted from some 1.5M$ in external research support. he worked with Allen Bard during a sabbatical leave in 1982 in Austin. As Associate Dean he won support from NSF-ARIP ($500,000) and the Ohio Board of Regents ($250,000) to renovate University research laboratories. A member of ACS, he is Alternate Councilor of the Dayton Section.

Teaching Faculty at the Midwest Center

- **David Johnson, Ph.D.**, Associate Professor. He earned his Ph.D. from the Illinois Institute of Technology with a dissertation entitled "Quantitative Estimates of Steric Effects: Structure and Reactivity of Some Cobalt (III) and Copper (II) Complexes." He teaches analytical chemistry and instrumentation.
- **James F. O'Brien, Ph.D.**, Professor and Distinguished Professor at Southwest Missouri State University. He earned his Ph.D. from the University of Minnesota and has been at Southwest Missouri State University since 1969. He has 21 publications in refereed journals and 12 externally-funded grants. He received the SMSU Excellence in Teaching Award in 1992 and SMSU Excellence in Research Award in 1994.
- **Robert G. Keil, Ph.D.** (See above.)

West Coast Center Assistant Director and Institute Faculty Member: Mark Wicholas, Ph.D.

Dr. Mark Wicholas is Professor and Chairperson of the Chemistry Department at Western Washington University. Upon receiving his Ph.D. in inorganic chemistry at the University of Illinois, Urbana in 1967. he took a teaching position at Western Washington University and has remained there except for periods of sabbatical leave, the most recent of which was at the University of British Columbia in 1991. His teaching interests include general and advanced inorganic chemistry, and most recently he helped create a two quarter, integrated inorganic/physical chemistry laboratory sequence. His research spans the fields of transition metal coordination chemistry and organometallic chemistry with emphasis on synthesis and spectroscopy. Areas of special interest include NMR spectroscopy of paramagnetic metalloporphyrins and oxidative addition reactions of substituted, zero-valent group 6 metal carbonyls. Dr. Wicholas has 29 publications to date, his research having been supported by grants from the Petroleum Research Fund of the American Chemical Society, Research Corporation, and NATO. He also most recently received two NSF-ILI grants for instructional laboratory instrumentation.

Teaching Faculty at the West Coast Center

- **Devon A. Cancilla, Ph.D.**, Visiting Assistant Professor. He is currently on a leave of absence from Environment Canada where he was Chief of Research and Methods at the National Laboratory of Environmental Testing.
- **Donald Pavia, Ph.D.**, Professor. He is a national award winning programmer of instructional material.
- **Donald King, Ph.D.**, Associate Professor. He uses AA/UV-VIS Diode Array in general chemistry and analytical instruction.

H. DESCRIPTION OF FACILITIES

This project will be implemented on the campuses of George Mason University in association with Northern Virginia Community College (East Coast Center), the University of Dayton in association with Sinclair Community College (Midwest Center), and the University of Western Washington in association with Shoreline Community College (West Coast Center).

George Mason University (East Coast Center)

George Mason University (GMU), the State University of Northern Virginia, is a rapidly growing institution with an enrollment of nearly 21,000 students and is expected to increase to 32,000 by the end of the century. Located in Fairfax, Virginia at the doorstep of the nation's capital, GMU has acquired a national reputation for innovation; yet it is rooted in the academic tradition of Virginia. George Mason University started as a two-year branch of the University of Virginia in 1957. In 1966 it was authorized to become a four-year degree-granting institution and in 1972 it was established as an independent state university. It is currently comprised of eight academic divisions of which the College of Arts and Sciences is the largest. GMU offers baccalaureate degrees in 53 areas; master's degrees in 44 areas, doctoral degrees in 10 areas, and a professional degree in law.

The chemistry department has 13 full-time faculty members and offers BA, BS, and MS degrees. In the past four years, the number of majors has more than doubled to 109 and the number of degrees conferred has increased from less than 10 per year to about 20 in the past two years. GMU has made a major commitment to the chemical sciences over the last few years by providing $12 million Science and Technology I Building in 1986 that chemistry shares with physics and mathematics. The modern laboratory facilities house many pieces of routine equipment for the undergraduate labs such as IR, UV-VIS and stopped flow spectrometers; gas and liquid chromatographs; 60 MHZ NMR spectrometers; atomic absorption and emission spectrometers. Equipment for advanced research such as an X-ray photoelectron/Auger electron spectrometer, preparative and ultracentrifuges and a computerized data-acquisition system is available. Additional instrumentation is available through the GMU Shared Research Instrumentation Facility, including quadrapole GC/MS systems, a Sun workstation, X-ray diffractometer, a Finnegan-MAT ion trap GC/MS, a DNA synthesizer, and soon the new 300 MHZ spectrometer.

The GMU chemistry faculty have been active in research as evidenced by their presentation of talks at regional, national, and international scientific meetings. They actively publish in referred journals (57 articles in 14 journals during the 1991-93 biennium). Many of the articles are co-authored by undergraduate students who are active in their senior research courses. The faculty is accustomed to a blend of teaching and research with significant student involvement.

Northern Virginia Community College

Northern Virginia Community College was established in 1964 as the Northern Virginia Technical College to serve the eighth planning district of the state of Virginia under the auspices of a statewide technical college system. This system was to serve twenty three regions under legislation enacted by the Virginia General assembly. In 1966 the Virginia Community College System was established with the purpose of complementing the missions of the secondary schools and the state's four year colleges and universities.

The college opened for classes in the fall of 1965 in a single building. Now, the College has five campuses serving the counties of Arlington, Fairfax, Loudoun, and Prince William, and the cities of Alexandria, Falls Church, Fairfax, Manassas Park and Manassas. With 39,250 credit students and a slightly larger number in continuing education courses enrolled in Fall semester, 1992 the growth of Northern Virginia Community College has paralleled that of its service area, and it is now one of the largest community colleges in the nation.

Chemistry is taught on each of the five campuses by eleven full-time faculty members (six with the Ph.D., five with Master's degrees, and two with doctorates in progress) and a number varying by semester of adjunct faculty. Although administered separately on each campus within divisions with various titles, course offerings are coordinated and standardized through a chemistry "cluster" and include university parallel courses transferable to science, engineering, health professionals and liberal arts schools

of universities and colleges throughout the country. In addition, course offerings serve a support function for certificate and applied science associate degree programs within the College. Chemistry enrollments have increased over the last several years with the most dramatic increase (over 90%) in the organic course for science majors.

University of Dayton (Midwest Center)

The University of Dayton is a private, coeducational school founded and directed by the Society of Mary (the Marianists), a Roman Catholic teaching order. It is among the nation's largest Catholic institutions of higher education. It was founded in 1850 and became the first permanent foundation for the Society of Mary in the western hemisphere. The University of Dayton (U.D.) is comprised of the College of Arts and Sciences and four professional schools: the School of Business Administration, the School of Education, the School of Engineering, and the School of Law. U.D. awards baccalaureate in 15 areas, masters degrees in 23 areas and five doctorates.

The Department of Chemistry was founded in 1909 by Dr. William J. Wohllenben. The department has enjoyed a long and distinguished record of achievement. As of 1986, more than 100 graduates have earned doctorates and have become leaders in research and industrial management. Over the past 10 years an average of 25 percent of the graduates from the B.S. degree have entered graduate schools. Some 50 graduates, mostly B.A. majors, have completed medial or dental studies.

The Chemistry Department occupies approximately 30,000 square feet of Wohllenben Hall. Undergraduate laboratories are safe and well-equipped. Routine equipment includes top loading digital analytical balances; pH meters; visible, ultraviolet, fourier-transform infrared spectrometers, atomic absorption spectrometers; and gas and liquid chromatography. Students experiment with various spectroscopic techniques including nuclear magnetic resonance, laser Raman, Fourier-Transform infrared, and ultraviolet. Ready access to minicomputers and the University's VAX mainframe computer is provided within the Department. Specialized equipment which supports

research in X-ray crystallography, biochemistry, chemical synthesis, and electro-analytical studies is also available for student use. The two key ingredients for an outstanding undergraduate education in chemistry, accessible full-time faculty, and modern equipment are present at the University of Dayton.

Members of the U.D. Chemistry faculty present talks at national and international scientific meetings, and have accounts of their research published in refereed scientific journals. Some of these have been co-authored by undergraduate students who have assisted in the research work. At the same time, the faculty believes that classroom teaching is of prime importance.

Sinclair Community College (Midwest Center)

Sinclair Community College, located in Dayton, Ohio, is a comprehensive two-year community college offering a diverse range of over 1,500 university parallel, technical, and career courses to a student body of nearly 21,000. In 1987 the College earned the maximum ten-year accreditation by the North Central Association of Colleges and Schools and is generally regarded as being in the national forefront in educational innovations and excellence. Sinclair is the largest single-campus community college in Ohio and one of the 20 largest in the United States. The 107-year old institution is located on a 20-year old campus in the urban inner-city. As a member of the League for Innovation in the Community College, Sinclair is one of the top 18 community colleges in the United States.

Sinclair recently built a $25 Million, 200,000 square foot facility housing the Sinclair Center for Corporate and Community Services and the Chemistry Department. The Chemistry Department, located in 12,760 square feet on the third floor of the Sinclair Center, is a state-of-the-art chemistry teaching facility. The nine-member Department includes five faculty with the doctoral degree, a full-time laboratory technician, modern lecture-demonstration rooms and labs, and a complete stockroom.

The Chemistry Department provides important support courses for Allied Health and Engineering students as well as instruction for Liberal Arts and Sciences transfer students. Richard Jones, Professor and Department Chair, has administered three recent grants from the National Science Foundation: a $26,015 Instrumentation and Laboratory Improvement Grant (1989-90); a $173,400 Undergraduate Faculty Enhancement Grant (1992-94); a $273,000 Undergraduate Faculty Enhancement Grant (1995-96).

Western Washington University (West Coast Center)

The Western Washington University has a current enrollment of 10,200 and is situated in Bellingham, Washington, a city of 55,000 on the coast north of Puget Sound almost equidistant between Seattle and Vancouver, British Columbia. Its student body is principally from within Washington and as a regional university, it also serves the special needs of the western half of the state. The chemistry department, which is in the College of Arts and Sciences, has 13 full-time teaching faculty. The department offers BA and BS degrees in chemistry, the latter being certified by the American Chemical Society. Also offered is a BS in biochemistry. The department also has a small MS program which covers biochemistry and the traditional areas of chemistry. In a typical year, the department has 125 students with declared majors an graduates 30 students. Approximately 33% of its students continue on to graduate or professional school.

In September 1993 the department moved into its new four-story, 65,000 sq. ft. building with state of the art facilities and equipment. Over $1.25 million in new laboratory equipment and instrumentation have been purchased in the past six years. Current available equipment include a Bruker 300 MHz NMR spectrometer, four Mattson FTIR spectrometers, three HP diode array UV/VIS spectrophotometers, two Hewlett-Packard gas chromatographs, a Waters HPLC system, a Hewlett-Packard GC/MS spectrometer, a Perkin Elmer Atomic Absorption spectrometer, five Silicon Graphics Unix workstations and a 21 station computer lab.

Shoreline Community College

Shoreline Community College, located 10 miles north of downtown Seattle, is a comprehensive two-year community college offering a diverse range of courses and technical programs, serving more than 7,500 academic students per quarter. The scenic and beautiful campus, nestled among native evergreens, comprises 24 buildings on an 83-acre campus. These include computer centers, laboratories, student center, theater, a well-equipped gymnasium, child care center, and the Ray W. Howard Library/Media Center. Shoreline's satellite, the Northshore Center was established in 1991 and has a state-of-the-art computer lab and is located next to the University of Washington Bothell branch campus.

The Chemistry Department, under the Science Division, offers a wide variety of courses which directly transfer to all major universities. The department's reputation as a source of excellent teaching is well known in the state. The students transferring to the University of Washington, Western Washington University or Washington State University have excelled in their programs. The high percentage of Shoreline students admitted every year into Pharmacy and Engineering programs is testimony to their preparation. Along with transfer courses, Shoreline has a highly successful Chemical Technology program, featuring a comprehensive instrumentation course which prepares students for direct entry into the work force. In the last four years, a Hazardous materials Handling and management Program has been developed and offers both a two-year degree and a one year certificate options.

5. LITERATURE CITED

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2. ***Critical Issues in Two-Year College Chemistry, Report of the 1985 Invitational Education Conference*** sponsored by the Society Committee on Education of the American Chemical Society, 1985.

3. ***FACT BOOK of Higher Education***, American Council on Education, 1987.

4. ***Minorities on Campus: A Handbook for Enhancing Diversity***, American Council on Education, 1989.

5. American Association of Community and Junior Colleges, ***Community College Times***, 1990.

6. ***Phase III Report Enhancing Transfer Effectiveness at Sinclair Community College***, National Effective Transfer Consortium, B.W. Associates, February 1993.

7. ***Guidelines for Chemistry and Chemical Technology Programs in Two-Year Colleges***, American Chemical Society, 1988.

6. BIOGRAPHICAL SKETCHES

Curriculum vitae are attached in Appendix E for the following project staff:

- Principal Director and Midwest Center Director: Richard F. Jones, Ph.D.
- East Coast Center Director, Martha W. Sellers, Ph.D.
- West Coast Center Director, Dr. Clarita C. Bhat, Ph.D.
- East Coast Center Assistant Director and Institute Faculty Member, Wayne M. Stalick, Ph.D.
- Midwest Center Assistant Director and Institute Faculty Member: R. Gerald Keil, Ph.D.
- West Coast Center Assistant Director and Institute Faculty Member: Mark Wicholas, Ph.D.

7. BUDGET

The attached three-year budget is comprised of the following components **for each year of the project**:

- Summary Spreadsheet
- Total Project Summary--Year One (NSF Form 1030)
- Sinclair Community College, Year One Budget (NSF Form 1030)
- Sinclair Community College, Year One Budget Explanation
- University of Dayton, Year One Subcontract Budget (NSF Form 1030)
- University of Dayton, Subcontract Budget Explanation
- Northern Virginia Community College, Year One Subcontract Budget (NSF Form 1030)
- Northern Virginia Community College, Year One Subcontract Budget Explanation
- George Mason University, Year One Subcontract Budget (NSF Form 1030)
- George Mason University, Subcontract Budget Explanation
- Shoreline Community College, Year One Subcontract Budget (NSF Form 1030)
- Shoreline Community College, Year One Subcontract Budget Explanation
- Western Washington University, Year One Subcontract Budget (NSF Form 1030)
- Western Washington University, Subcontract Budget Explanation

7. STATEMENT OF CURRENT AND PENDING SUPPORT

Jones

Keil

Stalick

Sellers

Bhat

Wicholas

Appendix A

1996 Final Report

Appendix B

2YC$_3$ Letter of Support

Appendix C

Sample Instrumentation Workshop Exit Evaluation 1996

Appendix D

Follow Up Evaluation

Appendix E

Vitae of Key Personnel