Research Division

Contractor: ICF Consulting Services

Contract # 07-330

FUNDING FISCAL YEAR	FY 07/08	FY 08/09	FY 09/10	
TERM	06/30/08-03/30/10	06/30/08-03/30/10	06/30/08-03/30/10	
PCA	72350	72350	72350	
LINE ITEM/OBJECT	418.20	418.20	418.20	TOTAL
DESCRIPTION	Perform life cycle analysis for GHG			
Contract $	$ 208,436.00	$ 59,553.00	29,776.00	$ 297,765.00
				$ -
				$ -
Total, Contract	$ 208,436.00	$ 59,553.00	$ 29,776.00	$ 297,765.00

Payments to Contractor:

Inv. #	Inv. Date	Ser Per				C/S
2008-107791	3/20/2009		53,597.70		53,597.70	C080643
2009-008-055	3/20/2009		26,798.85		26,798.85	C080643
					-	
					-	
					-	
					-	
					-	
					-	
					-	
					-	
					-	
					-	
					-	
					-	
					-	
					-	
					-	
					-	
Total, Payments			$ 80,396.55	$ -	$ -	80,396.55
Balance Available to Pay Contractor			$ 128,039.45	$ 59,553.00	$ 29,776.00	$ 217,368.45
Balance Must Be Spent By:			*6/30/2010*	*6/30/2011*	*6/30/2012*	

Notes:

Contract Manager: Whitney Leeman

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DUPLICATE

Research Division

Contractor: ICF Consulting Services

Contract # 07-330

FUNDING FISCAL YEAR	FY 07/08	FY 08/09	FY 09/10	
TERM	06/30/08-03/30/10	06/30/08-03/30/10	06/30/08-03/30/10	
PCA	72350	72350	72350	
LINE ITEM/OBJECT	418.20	418.20	418.20	TOTAL
DESCRIPTION	Perform life cycle analysis for GHG			
Contract $	$ 208,436.00	$ 59,553.00	29,776.00	$ 297,765.00
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						-	
						-	
						-	
Total, Payments			$ 80,396.55	$ -	$ -	80,396.55	
Balance Available to Pay Contractor			$ 128,039.45	$ 59,553.00	$ 29,776.00	$ 217,368.45	
Balance Must Be Spent By:			*6/30/2010*	*6/30/2011*	*6/30/2012*		

Notes:

Contract Manager: Whitney Leeman

42

C080643

RCVD MAR 23 '09

ICF INTERNATIONAL
9300 Lee Highway
Fairfax, VA 22031-1207
Telephone (703)934-3000 Fax (703)218-2547
Web http://www.icfconsulting.com

INVOICE

California Air Resources Board
Attn: Emma Plasencis, Contract Administrator
Research Division, ARB
1001 I Street
Sacramemto, CA 95814

Invoice Date: March 20, 2009
ICF Contract No.: 028273.0.001
ICF Invoice No.: 2008-107791

07-330

1/1/08 - 1/30/08

Description	*Current Invoice Amount*	*Cumulative Invoice Amount*
CARB: Global Warming GHG Destruction		
Task #0 - Kick-Off Meeting	$59,553.00	$59,553.00
Less 10% withhold	-$5,955.30	-$5,955.30
Subtotal: ICF Task(s)	$53,597.70	$53,597.70
TOTAL INVOICE AMOUNT DUE:	$53,597.70	

Approved by:

Authorized Financial Representative

PAYMENT APPROVED:

BARRY E. CROES, P.E.
CHIEF, RESEARCH DIVISION
DATE 4/1/09

Payment Due Net 30

Payment Options:

Wire Transfer:
Citizens Bank of Pennsylvania
ABA #: 036076150
Account Name: ICF Consulting Group, Inc.
Account # : 6203219502
Taxpayer ID: 54-1500263

Billing Questions: Call Michelene Pryor (703) 394-3236
or EMAIL MPryor@ICFConsulting.com

OR

Remit Payment To:
ICF Resources, LLC
PO Box 7777 - W510501
Philadelphia, PA 19175-0501
Please reference our contract and invoice numbers on your check

Contract Questions: Call Samuel Chambers (202) 862-1242
or EMAIL schambers@icfi.com

RCVD APR 6 2009

RCVD MAR 23 '0

ICF INTERNATIONAL
9300 Lee Highway
Fairfax, VA 22031-1207
Telephone (703)934-3000 Fax (703)218-2547
Web http://www.icfconsulting.com

INVOICE

California Air Resources Board
Attn: Emma Plasencis, Contract Administrator
Research Division, ARB
1001 I Street
Sacramemto, CA 95814

Invoice Date: March 20, 2009
ICF Contract No.: 028273.0.001
ICF Invoice No.: 2009-008055

07-330 (12/29/08 – 12/31/08)

Description	*Current Invoice Amount*	*Cumulative Invoice Amount*
CARB: Global Warming GHG Destruction		
Task #0 - Kick-Off Meeting	$0.00	$59,553.00
Task #1 - Literature Review Summary	$29,776.50	$29,776.50
Less 10% withhold	-$2,977.65	-$8,932.95
Subtotal: ICF Task(s)	**$26,798.85**	**$80,396.55**
TOTAL INVOICE AMOUNT DUE:	**$26,798.85**	

Approved by:
Authorized Financial Representative

PAYMENT APPROVED:
for
BART E. CROES, P.E.
CHIEF, RESEARCH DIVISION
DATE 4/1/09

Payment Due Net 30

Payment Options:

Wire Transfer:
Citizens Bank of Pennsylvania
ABA #: 036076150
Account Name: ICF Consulting Group, Inc.
Account # : 6203219502
Taxpayer ID: 54-1500263

Billing Questions: Call Michelene Pryor (703) 394-3236
or EMAIL MPryor@ICFConsulting.com

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PO Box 7777 - W510501
Philadelphia, PA 19175-0501
Please reference our contract and invoice numbers on your check

Contract Questions: Call Samuel Chambers (202) 862-1242
or EMAIL schambers@icfi.com

RCVD APR 6 2009

STATE OF CALIFORNIA
STANDARD AGREEMENT
STD 213 (Rev 06/03)

AGREEMENT NUMBER
07-330
REGISTRATION NUMBER

1. This Agreement is entered into between the State Agency and the Contractor named below:

STATE AGENCY'S NAME
Air Resources Board (ARB)

CONTRACTOR'S NAME
ICF Consulting Services, LLC

2. The term of this Agreement is: **DGS approval or through By June 30, 2008, whichever is earliest** **24 months**

3. The maximum amount of this Agreement is: **$ 297,765.00** **Two Hundred Ninety-Seven Thousand, Seven Hundred Sixty-Five Dollars and no cents.**

4. The parties agree to comply with the terms and conditions of the following exhibits which are by this reference made a part of the Agreement.

Exhibit A – Scope of Work	5 pages
Exhibit A, Attachment 1 – Technical Proposal	130 pages
Exhibit B – Budget Detail and Payment Provisions	2 pages
Exhibit B, Attachment 2 – Cost Proposal	43 pages
Exhibit C* – General Terms and Conditions (GTC-307)	On-line
Exhibit - D Special Terms and Conditions (Attached hereto as part of this Agreement)	2 pages
Exhibit E – Additional Provisions	8 pages
Attachment 1* – Contractor Certification Clauses (CCC-307)	On-line
Exhibit F - Final Report Format	6 pages

Items shown with an Asterisk (*), are hereby incorporated by reference and made part of this agreement as if attached hereto.
These documents can be viewed at www.ols.dgs.ca.gov/Standard+Language

IN WITNESS WHEREOF, this Agreement has been executed by the parties hereto.

CONTRACTOR

CONTRACTOR'S NAME *(if other than an individual, state whether a corporation, partnership, etc.)*
ICF Consulting Services, LLC

BY *(Authorized Signature)* — DATE SIGNED *(Do not type)*: 6/15/8

PRINTED NAME AND TITLE OF PERSON SIGNING
Laurence Rose, Vice President, Director of Contracts

ADDRESS
9300 Lee Highway
Fairfax, VA 22031

STATE OF CALIFORNIA

AGENCY NAME
Air Resources Board

BY *(Authorized Signature)* — DATE SIGNED *(Do not type)*: 6/4/08

PRINTED NAME AND TITLE OF PERSON SIGNING
Socorro Watkins, Chief, Business Management Branch

ADDRESS
P.O. Box 2815 Sacramento, CA 95812

California Department of General Services Use Only

APPROVED
JUN 25 2008
DEPT OF GENERAL SERVICES

☐ Exempt per:

EXHIBIT A
Standard Agreement

SCOPE OF WORK

1. Contractor agrees to provide to Air Resources Board (ARB) services as described herein:
4. The project representatives during the term of this agreement will be:

State Agency: Air Resources Board		Contractor: ICF Consulting Services, LLC	
Name:	Emma Plasencia	Name:	Laurence M. Rose
Address:	1001 I Street, 5th floor Sacramento, CA 95814	Address:	9300 Lee Highway, Fairfax, VA 22031
E-Mail:	eplasenc@arb.ca.gov	E-Mail:	LRose@icfi.com
Phone:	(916) 323-1524	Phone:	(703) 934-3557
Fax:	(916) 322-4357	Fax:	(703) 218-2547

Direct all administrative inquiries to:

State Agency: Air Resources Board		Contractor: Mark Wagner	
Section/Unit:	Research Division	Section/Unit:	Sr Vice President
Attention:	Dory Kramer	Attention:	
Address:	1001 I Street, 5th floor	Address:	9300 Lee Highway, Fairfax, VA 22031
E-Mail:	dkramer@arb.ca.gov	E-Mail:	mwagner@icf.com
Phone:	(916) 445-4444	Phone:	(202) 862-1155
Fax:	(916) 327-2940	Fax:	

5. **Description of Services:**

The objective of the project will be to perform lifecycle analysis (LCA) to evaluate different recovery and destruction or re-use options for high global warming potential (GWP) greenhouse gases (GHGs) in California. CO2-equivalent (CO2-E) emissions rates and monetary costs associated with disposal, transport, recovery, and re-use or destruction of high-GWP GHGs from discarded appliances, decommissioned equipment, construction and demolition (C&D) waste as well as stockpiled or recovered/reclaimed chemicals will be quantified and compared to business-as-usual (BAU). Under the BAU scenario, high-GWP GHGs are recovered, reclaimed, and recycled where possible; refrigerants from compressors are recovered, reclaimed, and recycled, while foams are generally shredded and landfilled. Generation of hazardous waste and/or toxic emissions associated with waste destruction for each alternative will be evaluated and estimated.

The lifecycle costs and benefits of recovery and re-use or destruction of high GWP GHGs in each application will be estimated in terms of CO2-E emissions, non-GHG emissions (i.e. criteria pollutants, air toxics, hazardous solid or liquid waste generation, etc.), and monetary expenses.

High-GWP GHG emissions scenarios comparing business-as-usual (BAU) vs. controlled will be examined for each year out to 2020 for each of the various recovery and destruction or re-use scenarios, to estimate possible CO2-E GHG reductions and the associated monetary costs based on lifecycle considerations associated with transport, recovery, and re-use or destruction of high-

EXHIBIT A
Standard Agreement

GWP GHGs. Emissions and costs associated with control, treatment, and disposal of potentially toxic byproducts will also be estimated.

BACKGROUND:
With the passage of Global Warming Solutions Act of 2006 (AB 32), the California Air Resources Board (ARB) is charged with developing and implementing workplans to enable the State of California to reach its goal of CO_2-E GHG emission reductions to 1990 levels by 2020.

ARB is considering proposing regulations to recover and destroy ozone depleting substances (ODSs) and other high-GWP GHGs from appliances, construction and demolition waste, decommissioned equipment/systems, chemical stockpiles, spent chemicals from industrial processes, etc. A need exists for an energy-efficient, cost-effective protocol to mitigate the potential GHG emissions from these materials.

For insulating foams used in buildings and residential appliances such as refrigerators, freezers, and some air conditioners, options include the following:

1) Business-as-usual (shredding and landfilling foams containing high-GWP blowing agents);
2) Enhanced recovery of foams and/or blowing agents; and
3) Destruction of recovered foams or blowing agents, or re-use of the recovered blowing agents.

For high-GWP GHGs recovered from any applications/processes, including those recovered from insulating foams, the following options exist:

1)Construction of one or several facilities to process discarded appliances and recover high-GWP GHGs onsite. The recovered high-GWP GHGs could be recycled and re-sold, destroyed onsite, or shipped out of state for destruction (see item 4, below). If the processing facility were designed to destroy high-GWP GHGs onsite, other high-GWP GHGs could be transported to, and destroyed at, such newly-constructed facilities;
2)Utilization of mobile processing and/or destruction systems for recovered high-GWP GHGs;
3)Utilizing in-state facilities, such as cement kilns or other high-temperature hazardous waste destruction facilities (such as RCRA facilities or others having acceptable destruction methodologies as specified in the Montreal Protocol) to incinerate high-GWP GHGs; and
4)Shipping recovered high-GWP GHGs out of state for destruction.

Due to their high GWPs, the types of chemicals that are of immediate concern are the banked ODSs (CFCs, HCFCs, Halons) in old refrigeration and A/C equipment, foams, fire extinguishing equipment, and chemical stockpiles. Other high-GWP GHGs that are candidates for a recovery and destruction protocol are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), nitrogen trifluoride (NF_3), sulfur hexafluoride (SF_6), and possibly hydrofluoroethers (HFEs) or perfluoropolyethers (PFPEs).

EXHIBIT A
Standard Agreement

Technical Plan

Task 1: Literature Review
The contractor shall conduct a review of published literature, reports, industry databases, etc., relevant to the topics of high-GWP GHG recovery, disposal, and destruction, based on acceptable methods specified by the Montreal Protocol, including any projected future high-GWP GHG recovery and destruction technologies[1]. Data regarding current and future numbers of appliances, non-appliance foams, fire extinguishers, and other high-GWP GHGs to be destroyed will be gathered from published sources, and from local, state, and federal government agencies, including ARB, where possible.

Deliverable: This task will conclude with a report summarizing the relevant literature. The report will discuss implications for the project's research plan, and shall include a detailed bibliography. The contractor, being familiar with and possibly contributing to, the peer-reviewed literature, shall not expend more than five percent of the overall project budget on this task.

The aforementioned report will not be subject to separate review by the ARB's Research Screening Committee. The contractor may treat this report as a draft of an element of the final report of the project. This report should be presented to the ARB contract manager prior to completion of Task 2.

Task 2: Refined Research Plan
The contractor shall present a fully developed research plan describing the necessary steps for the development of emissions scenarios for high-GWP GHG recovery and destruction options in California vs. BAU, based on LCA. Given the uncertainty in the inventory of banked high-GWP GHGs to be disposed of in the next several decades, the contractor should develop an approach to estimate LCA emissions that is elastic enough to account for variability in estimates of material flows.

Forecasts for years out to 2020 will involve estimating future high-GWP GHG emissions from chemical banks under both BAU and recovery/destruction scenarios, based on their associated sector growth rates and residence times in equipment, products or processes. The contractor will estimate the errors in the forecasts due to uncertainties in projecting the abovementioned changes.

The research plan will include a detailed work plan and project schedule.

Deliverable: This task will conclude with submittal of a refined and revised research plan, work plan and project schedule. The refined research plan, which may integrate the deliverable from Task 1, will be subject to review by the ARB contract manager. The contractor may treat the research plan as a draft of an element of the final report of the project. This deliverable should be submitted prior to completion of Task 3.

---

[1] The Montreal Protocol-approved destruction processes should be relied on first and foremost, as ODSs will account for a large portion of the high-GWP GHGs to be destroyed, based on their large bank sizes. See the following link for a brief description of acceptable destruction technologies:
http://www.uneptie.org/Ozonaction/topics/disposal.htm

EXHIBIT A
Standard Agreement

Task 3: Data Analysis
The contractor shall undertake a detailed, comprehensive LCA of BAU as well as the various high-GWP GHG destruction options, and will use forecasting to predict costs and benefits associated with recovery and destruction of such chemicals for each year out to 2020.

Deliverable: A report containing detailed tables or spreadsheets denoting lifecycle emissions (CO_2E as well as any other criteria pollutant and toxic emissions) and costs associated with each step of end-of-life (EOL) recovery, transport, and destruction of high-GWP GHGs, including control and disposal of their byproducts for each year out to 2020. The tables or spreadsheets will also contain the lifecycle emissions and costs associated with BAU for each year out to 2020. This report should be presented prior to completion of Task 4.

Task 4: Draft and Final Reports
A draft report shall be prepared by the contractor and submitted to ARB and to outside reviewers for review and comment. The draft report will include discussions, analyses, descriptions of data collected, presentation of research methodology and results for all preceding tasks. The draft report will include the tables/spreadsheets (described in Task 3) summarizing the LCA results in terms of CO_2-E, monetary costs, and generation of toxic emissions or hazardous wastes for each high-GWP GHG destruction option as well as BAU. Also included will be a figure summarizing the BAU CO_2-E emissions and forecasted reductions due to various destruction strategies for each year out to 2020, with error bars and a discussion of uncertainties.

A Final Report shall be prepared by the contractor and submitted to ARB. The contractor's work plan shall allow for a period of no less than six months from submittal of the draft report until submittal of the final report. This final report will be subject to formal review by the Research Screening Committee.

Deliverables: Quarterly progress reports, draft, and final reports. See Appendix VI for format requirements.

MEETINGS
Prior to beginning the contracted work, the principal investigator and key personnel shall meet with the ARB contract manager and other ARB staff. The meeting location will be at ARB's offices in Sacramento and will cover the overall project plan, details of performing the tasks, the project schedule, items related to personnel or changes in personnel, and any issues that should be resolved before work can begin.

The contractor will participate in regular progress meetings with the ARB project monitor and other ARB staff. These meetings will most likely take the form of telephone conferences. The interval between meetings should be no more than quarterly, and may be more frequent as deemed necessary by the ARB contract manager. The contractor should be prepared for open, two-way communication with the ARB contract manager throughout the course of the project.

Within two months subsequent to the completion of the project and the formal approval of the final report, the contractor will present a technical seminar to ARB staff and other interested parties. The seminar will cover the entire project including the purpose, methodology and results. The seminar will take place at ARB's facilities at a date and time to be coordinated through discussion with the ARB project monitor.

EXHIBIT A
Standard Agreement

CONTRACT DELIVERABLES

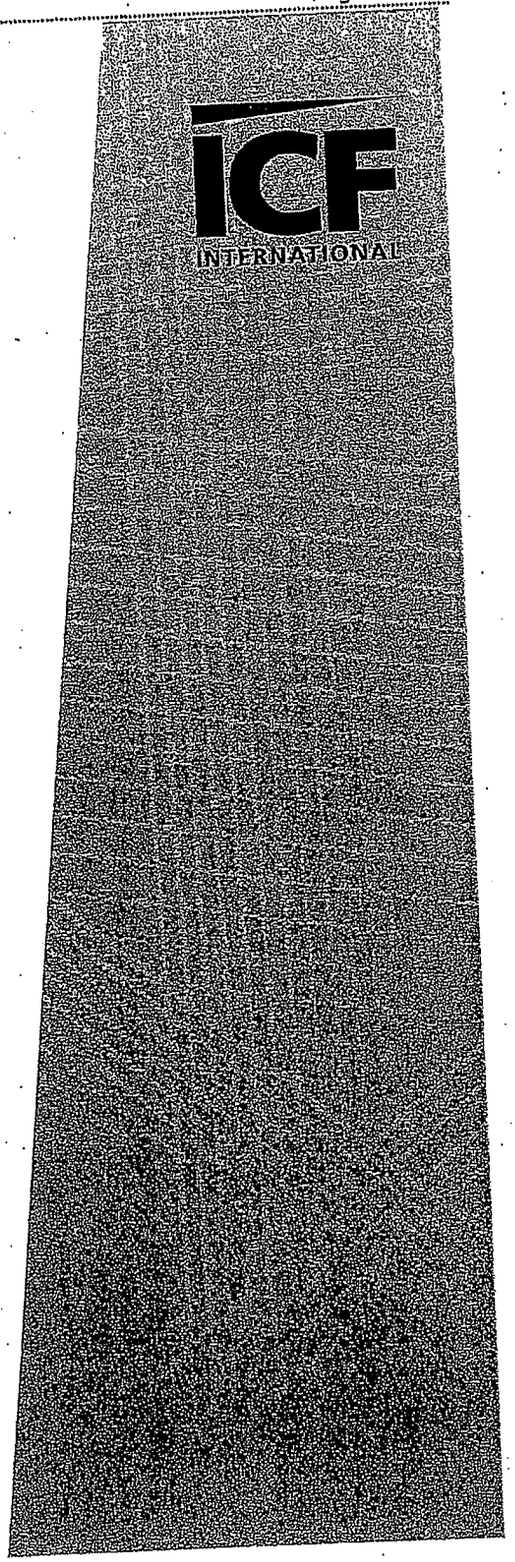
In addition to the deliverables listed in the statement of work, the contractor will provide quarterly invoices and electronic progress reports. These progress reports will completely discuss the status of the project to date, the progress since the previous progress report, significant problems addressed during the quarter, significant problems to be addressed in the next quarter, and work planned for the next quarter. The quarterly progress report should also quantify the percentage of work accomplished to date and percentage of budget used to date. Finally, the progress report should make a statement about any need to revise the schedule or budget class amounts to reflect changes needed over the existing schedule or budget.

Six months prior to the contract termination date, the contractor will deliver 20 bound copies of a draft final report and one electronic copy to the ARB, for review by ARB staff. The printed reports may be stapled or spiral bound, depending on size. Do not add a company cover to the bound copies; the title page should be the first visible page. The draft final report will conform to the Research Contract Final Report Format, Appendix VII.

Together with the final report, the contractor will deliver a set of all data compilations in a format specified by the ARB contract manager.

ICF INTERNATIONAL

Lifecycle Analysis of High-Global Warming Potential Greenhouse Gas Destruction



February 14, 2008

Prepared for:

Air Resources Board
Contract Services Section
1001 I Street, 20th Floor
Sacramento, CA 95814

ORIGINAL

February 2008

February 14, 2008

Sharon Simmons
Air Resources Board
Contract Services Section
1001 I Street, 20th Floor
Sacramento, CA 95814
Ref: RFP Number 07-330

Dear Ms. Simmons,

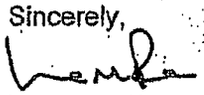
ICF Consulting Services, LLC (an ICF International company) is pleased to submit this response to Request for Proposal (RFP) Number 07-330, **Lifecycle Analysis of High-Global Warming Potential Greenhouse Gas Destruction**. The ICF Team, which includes two subcontractors Life Cycle Associates, and SDV-SCC, comprises highly experienced individuals that offer significant expertise in performing lifecycle analyses and in end-of-life options for high-global warming potential (high-GWP) greenhouse gas (GHG). We are confident that our history of quality services in the high-global warming potential GHG industry for national and state entities, as well as private corporations, offer the California Air Resources Board superb capabilities for the requested services.

The ICF Team includes the following partners:

- **ICF Consulting Services, L.L.C.**—a leading US-based policy and research consulting firm with experience in lifecycle analyses, recovery and destruction options for all of the high-GWP sectors, and preparing detailed assessments of high-GWP GHG emission scenarios.
- **Life Cycle Associates**—specializes in analyzing emissions and energy use on a complete lifecycle basis. They are experienced creating analyses for fuel cycles, processes, economics, and GHG strategies.
- **SDV-SCC, Inc.**, a Disabled Veteran Business Enterprise (DVBE) and Small Business Enterprise (SBE), with experience in lifecycle assessment and expertise in organization and financial management, organization development, and systems planning and implementation.

The attached Technical Proposal describes our proposed methodology and staff for this project. Our proposal includes signatures on required enclosures by our authorized binding official, Laurence M. Rose. We look forward to the opportunity to work with ARB. Please feel free to contact Mark Wagner, Project Manager, at 202-862-1155, should you have any questions or require additional information. For contractual inquiries, please contact Nakia Adams, Contract Manager, at 703-934-3646 or nadams@icfi.com.

Sincerely,



Laurence Rose
Vice President, Director of Contracts
703-934-3557
LRose@icfi.com

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1 Abstract

Under the California Global Warming Solutions Act (AB 32), the California Air Resource Board (ARB) is mandated to develop and implement strategies that allow the State of California to reduce greenhouse gas (GHG) emissions to 1990 levels by 2020. In response, ARB must thoroughly evaluate GHG emission reduction opportunities from all sectors, including those using non-CO_2 high global warming potential (high-GWP) GHGs such as HFCs and ozone depleting substances (ODS) (which are also high-GWP gases, though not covered under the United Nations Framework Convention on Climate Change or the Kyoto Protocol). In order to facilitate emission reductions of these gases ARB has identified a need to manage emissions at equipment end of life. As such, ARB has proposed options for recovery and reuse or destruction of these gases. However, the complete monetary and climate costs of these proposed options are not established, thus a comprehensive assessment must be performed of both the potential quantities of these gases that could be affected, and the costs and benefits of applying each of the options. Armed with this knowledge, ARB can target programs that maximize reductions of ODS and GHG emissions while minimizing costs, with the co-benefit of mitigating stratospheric ozone depletion, along with the intended goal of reducing GHG emissions.

ICF International (ICF), a technical, economic, and public policy consulting firm, with more than 3,000 employees, three offices in California, and more than 25 offices globally, has assembled a strong team to support this ARB initiative. The ICF Team proposes to develop a thorough, ISO-compatible, lifecycle assessment of the business-as-usual scenario and alternative recovery and destruction options for ODS and high-GWP gases from domestic appliances, decommissioned equipment, construction waste, chemical stockpiles, and other industrial sources. In addition, we will generate an inventory of emissions along each lifecycle phase.

The ICF Team offers an outstanding group of professionals with expertise in all the high-GWP gas sectors and in conducting lifecycle assessment. Our team has extensive lifecycle inventory experience, particularly as it relates to GHG emissions, energy use, and the impact of waste disposal decisions on emission levels and energy consumption. Additionally, ICF is recognized as a world leader in estimating GHG emissions. In addition to supporting the US Environmental Protection Agency in the development of every annual *Inventory of U.S. Greenhouse Gas Emissions and Sinks* since 1990, we have participated in the preparation of over 40 state GHG emission inventories, including California. We have conducted countless technical, economic, and environmental policy analyses in the foam blowing, refrigeration and air-conditioning, solvent cleaning, fire extinguishing, and other sectors that use ODS and high-GWP gases.

In addition to ICF experts, the ICF Team includes Life Cycle Associates, a premier firm specializing in lifecycle analysis with a long history supporting such analyses in California. Our Team also includes SDV-SCC, a service disabled veteran owned business, that will augment the Team's lifecycle analysis and analytical capabilities.

The hallmarks of the ICF Team's approach are experience and integration. We recognize the need for credible, current data, and for consistent lifecycle boundaries and assumptions. Having designed and implemented a framework to convert information on lifecycle processes into GHG and energy factors that are consistent with the Intergovernmental Panel on Climate Change guidance for estimating GHG emissions, we are uniquely well-qualified to apply our expertise to developing a state-of-the-art lifecycle assessment for the recovery, reuse, or destruction of ODS and high-GWP gases in the state of California.

2 Management

Prime Contractor:	ICF Consulting Services, LLC
Corporate Headquarters:	9300 Lee Highway Fairfax, VA 22031
Authorized Binding Official:	Laurence M. Rose Vice President, Director of Contracts (703) 934-3557
Technical Official:	Mark Wagner (202) 862-1155
Branch office:	ICF Consulting Services, LLC 394 Pacific Avenue, 2nd Floor San Francisco, CA 94111-1715
Subcontractors:	Life Cycle Associates 985 Portola Rd Portola Valley, CA 94028
	SDV-SCC, Inc. 205 De Anza Blvd., Suite 26 San Mateo, CA 94402

The proposed ICF Team is available to begin work for ARB immediately, upon contract award.

3 Methodology

3.1 Objective

The objective of this project is to perform a lifecycle analysis for the California Air Resources Board (ARB) to evaluate the various end-of-life management scenarios for ozone depleting substances (ODS) and other high global warming potential (high-GWP) greenhouse gases (GHG) in California through 2020—namely CFCs, HCFCs, halons, HFCs, PFCs, NF_3, SF_6, HFEs, and/or PFPEs. While ODS and other high-GWP GHGs are not the most abundant source of GHGs in California, they have the ability to trap heat in the atmosphere on the order of 140 to 23,900 times more effectively than carbon dioxide (CO_2). Additionally, these gases are often stored in equipment or products for long periods, often leaking slowly over time; in the absence of strategies to recover and destroy these gases, most will eventually be emitted to the atmosphere. Therefore, they represent an important source of emissions, and an important source of potential emission *reductions*—which can be used to meet the goals of the California Global Warming Solutions Act (AB 32) of reducing California's GHG emissions to 1990 levels by 2020.

As large stocks of products and equipment that contain ODS and other high-GWP GHGs—such as refrigeration and air-conditioning (AC) equipment, fire extinguishers, and building foams—reach the end of their useful lifetimes, it is critical to ensure that the ODS/GHGs are recovered for reuse or destruction, in order to prevent emissions. Likewise, chemical stockpiles of these high-GWP GHGs may be held by a wide range of players across different sectors—including electric power, electronics and precision cleaning, aerosols, and fire protection systems; such stockpiles, if unwanted, must be collected for destruction to prevent leakage associated with indefinite storage or accidental release. Many options exist to recover, collect, transport, and reuse (reclaim) or destroy such banks of high-GWP GHGs. But identifying which management options are most effective from both a cost and environmental perspective requires an in-depth lifecycle analysis. For example, the CO_2 emitted from the collection, transport, and demanufacturing of appliances from remote locations may offset any emissions savings from destruction of the high-GWP refrigerants and foam blowing agents. Alternatively, destruction of bulk stockpiles will likely yield clear emission savings.

This project aims to quantify the emissions (GHGs, ODS, criteria pollutants, toxics) associated with projected baseline and alternative scenarios for collecting and managing high-GWP GHGs contained in equipment, products, and chemical stockpiles. In order to do so, the current and projected banks of these chemicals in California must be estimated, baseline practices must be understood, and reasonable scenarios for alternative management practices must be identified. Next, lifecycle analyses must be conducted to quantify the full costs and benefits associated with each management scenario, so that the ARB can evaluate the most viable options to pursue.

3.2 Approach Overview

ICF proposes a comprehensive approach for providing ARB with a robust lifecycle analysis of high-GWP GHG recovery and disposal options. We have assembled a team of firms and consultants (the ICF Team) that possesses unparalleled expertise in the development of emission inventories and evaluation of abatement options for ODS and high-GWP GHG sectors, end-of-life management, and lifecycle analysis.

The strength of ICF's approach is based on an unparalleled understanding of ODS and high-GWP gases, their uses and emissions, and alternatives for destruction. This experience combined with our expertise in lifecycle analysis, emission inventories, and estimating the costs and benefits of emission reduction alternatives, will provide ARB with a comprehensive analysis of options for managing high-GWP GHGs. The Team's technical knowledge allows for a firm understanding of actual and potential options for the recovery, collection, and disposal of high-GWP GHGs in California; we know where the largest sources of chemical banks can be found, where the greatest opportunity for emission reductions may lie, and what means and processes may be most cost-effective for achieving those reductions. Moreover, we recognize the need for credible, current data, and for consistent lifecycle boundaries and assumptions. Having designed and implemented a framework to convert information on lifecycle processes into GHG and energy factors that are consistent with the Intergovernmental Panel on Climate Change guidance for estimating GHG emissions, we are uniquely qualified to apply our expertise to solve problems and identify opportunities for emission reductions for private sector enterprises and public agencies, alike.

ICF proposes the following approach for conducting this analysis for ARB:

- At the outset of the project, ICF will work with ARB to develop a clear understanding of project needs and constraints, and ensure that the research plan and schedule are designed to generate the desired results.
- ICF will then conduct a literature review to augment the ICF Team's existing knowledge of high-GWP GHGs in the sectors outlined in the Statement of Work (SOW). This literature review will be used to develop a refined research plan to define the baseline and alternative scenarios for recovery and destruction of high-GWP GHGs,[1] and describe the methodologies and data sources that will be used in defining the system boundaries and preparing a lifecycle analysis for each one.
- The ICF Team will then conduct the detailed lifecycle analysis for each baseline and alternative scenario, and summarize the findings in a draft and final report.
- Based on the results, ICF will provide a technical seminar describing the project to ARB staff.

The ICF Team believes that the results of this approach will place ARB in a strong position for developing emission reduction strategies within the relevant sectors.

Understanding

The ICF Team has developed an approach that is based on our unique understanding of high-GWP GHG sectors, end-of-life chemical management, and lifecycle analyses (see Exhibit 3-1). ICF understands the need for ARB to include destruction of high-GWP GHGs as part of a robust, comprehensive GHG emission reduction strategy. While emissions from these sectors are relatively low, reduction opportunities can be especially effective–and often are cost effective relative to other options to reduce CO_2--due to the gases' high-GWPs.

[1] ODS will include CFCs, HCFCs, and halons; other high-GWP gases will include HFCs, PFCs, NF_3, SF_6, HFEs, and/or PFPEs.

- *We understand the sources of high-GWP GHGs*: ICF's understanding of the high-GWP GHGs and sectors is unparalleled; we boast more than 25 years of experience related to stratospheric ozone projection, and have conducted countless technical studies related to the recovery and reclamation/destruction of ODS and other high-GWP GHGs. For the California Energy Commission (CEC), ICF prepared a report on the mitigation opportunities of high-GWP GHGs within the state. Globally, we have explored the costs, benefits, and effectiveness of a wide variety of programs for recovering, collecting, and reusing/destroying high-GWP GHGs contained in appliances and in bulk worldwide. For example, ICF is currently conducting a study on the collection and destruction of unwanted ODS contained in appliances and in bulk for the United Nations Environment Prorgamme (UNEP). Under this project, ICF is reviewing the procedures in place for collecting and disposing of ODS in nine countries—including the US—in order to assess effectiveness and develop management guidance for developing countries. As part of this study, ICF has visited and reviewed testing data from several destruction and reclamation facilities in the U.S. and around the world.

Exhibit 3-1: Key ICF Team Expertise

Key Expertise	High-GWP GHG Sectors	End-of-Life Management of ODS/High-GWP GHGs	Lifecycle Analysis
Key Clients	California Energy Commission, U.S. EPA, European Commission, Australia Greenhouse Office	U.S. EPA, UNEP, UNDP, European Commission	U.S. EPA, Wal-Mart, Toyota, Oregon Department of Environmental Quality, Environment Canada, GTZ, Canadian Renewable Fuels Association, Dow Chemical
Key Projects	• Report on Potential Mitigation Opportunities for Non-CO2 GHGs in California • U.S. EPA's Vintaging Model on ODS and high-GWP sectors • Analyses on remaining ODS banks and stockpiles for the U.S. EPA • Report on Global Mitigation of Non-CO2 Greenhouse Gases report • Measurement of PFC emissions and efficiency of PFC abatement devices at semiconductor facilities • SF6 Emission Reduction Partnership for Electric Power Systems • Study on remaining uses of halon and available alternatives in EU	• Analysis of ODS Destruction in the U.S. and Abroad • CCX Protocol: Destruction of ODS • Study on the Collection and Destruction of Unwanted ODS in Appliances and Bulk Worldwide • Vietnam Mobile Air Conditioner Recovery & Recycling Project • China Commercial Refrigeration Management Project • EC Best Available Technologies and Practices for Minimizing Emissions of ODS • Minimum Qualification Requirements for Leak Detection, Recycling, Recovery, Reclamation, and Destruction of ODS and High-GWP GHGs	• Comparative Lifecycle Analysis of Brazilian Sugarcane Ethanol and North American Ethanol • Lifecycle Climate Performance (LCCP) Analysis for Foams Used in Residential and Commercial Construction Applications • Costs and Benefits of a Biomass-to-Ethanol production industry in California • Lifecycle GHG and energy emission factors for more than 25 materials, types and categories • *Solid Waste Management and Greenhouse Gases: A Life-cycle Assessment of Emissions and Sinks* • Energy and GHG routing calculation tools: the Waste Reduction Model (WARM), the Recycle Economy Tool, Resource, and the Durable Goods Calculator (DGC)

- *We understand the options for reducing emissions*: ICF has supported the development and implementation of the U.S. EPA's voluntary Responsible Appliance Disposal (RAD) Program. As part of this project, ICF conducted research on the current state of appliance disposal in the United States, and has developed a cost-benefit assessment of appliance recycling programs to understand and justify the need for such a voluntary program. Finally, ICF has recently developed a methodology for determining the GHG emissions saved by the destruction of ODS for the US EPA. The latter project involved conducting extensive research on various ODS management scenarios, including their emission factors and costs, and supporting the creation of a project protocol to determine the emissions savings from potential projects to be used as emissions offsets under the Chicago Climate Exchange (CCX).[2]

- *We understand the lifecycle issues associated with reduction options*: ICF also offers an outstanding group of professionals with expertise in lifecycle assessment. Our team includes staff with extensive lifecycle inventory experience, particularly as it relates to GHG emissions, energy use, and the impact of waste disposal decisions on emission levels and energy consumption. ICF's subcontractor, Life Cycle Associates, specializes in analyzing emissions and energy use on a complete lifecycle basis, and has developed analytical approaches that take into account the environmental constraints that apply uniquely to California. Subcontractor SDV-SCC, Inc. further enhances the Team's experience in lifecycle assessment.

- *We understand the California market:* An understanding of the California market will be critical for estimating a business-as-usual (BAU) scenario and projected emission trends. Having supported EPA's RAD Program and other work for Appliance Recycling Centers of America, Inc. (ARCA), ICF has developed robust data on the number of household appliances disposed in California every year, as well as the number of units collected and responsibly recycled/destroyed by California utility appliance recycling programs. Through these projects, ICF has developed strong networks of industry contacts that can be relied upon for future information collection needs.

  In addition to the appliance sector, ICF understands where other accessible banks and stockpiles of high-GWP GHGs are most likely to be found in the state of California. ICF staff based in San Francisco and Los Angeles have been providing regulatory support related to GHG emission reductions to ARB, the CEC, the California Department of Transportation (Caltrans) and other California entities, such as the California Public Utilities Commission. For example, ICF has developed the California Inventory of Greenhouse Gas Emissions and Sinks for the CEC, and estimated the costs of reducing GHG emissions from non-CO_2 gases in California. Similarly, ICF is currently modeling GHG reduction measures to support the implementation of AB 32 for the ARB, and producing a guidebook for Caltrans designed to help transportation professionals analyze energy and GHG impacts during transportation planning, project development, and operations. This California-specific knowledge will allow the ICF Team to develop an analysis that adequately considers changes in population, economy, and regulation, and

[2] In 2007, this protocol was accepted as the world's first and only ODS offset project type that provides carbon credits to entities for the destruction of ODS.

the impact such changes will have on future ODS and high-GWP GHG emissions and management scenarios through 2020.

In short, the ICF Team offers what other teams cannot: unparalleled technical expertise in high-GWP GHGs, end-of-life management of ODS/high-GWP GHGs, and lifecycle analysis, all within the context of the California market.

4 Work Plan and Work Schedule

This section outlines the specific steps that the ICF Team proposes to undertake for this project, including:

- Task 0: Conduct project management and begin the project with a kick-off meeting to ensure that ICF and ARB have a common understanding of project goals, identify available data, and discuss timelines.
- Task 1: Conduct a literature review to augment the ICF Team's existing knowledge of ODS and other high-GWP GHGs in the sectors outlined in the Statement of Work (SOW).
- Task 2: Refine the research plan, based on the literature review, in which we will define the scenarios for recovery and destruction of ODS and other high-GWP GHGs[3] to be assessed, and describe the methodologies and data sources to use in preparing lifecycle analyses for each one.
- Task 3: Implement the refined research plan to estimate lifecycle emissions, costs, and benefits for each scenario.
- Task 4: Report results of the analysis and respond to ARB comments.
- Task 5. Present a technical seminar to ARB describing the project results.

Task 0: Project Management and Kick-Off

To initiate the work, ICF will meet with ARB at ARB's offices in Sacramento. This project kick-off meeting will ensure that there is consensus between ICF and ARB on project goals, milestones, constraints, and sensitivities. Specifically, the meeting agenda will include the overall project plan, details of performing tasks, project schedule, project personnel, and other issues that need to be resolved prior to initiation of work on Task 1 of the project. In preparation for the kick-off meeting, ICF will prepare a draft project plan and draft project schedule and will present these draft documents for discussion at the meeting. Any changes made to the project plan or schedule will be incorporated into the revised research plan (see Task 2). For budgeting purposes, it is assumed that the ICF Project Manager and one other key staff person will travel from San Francisco to Sacramento for this meeting.

ICF will conduct quarterly project meetings (at a minimum) with the ARB Project Monitor and other ARB staff. ICF anticipates that these project meetings will primarily be conducted through telephone conferences, however, ICF Project Management staff located in San Francisco will also be available to attend in-person meetings at ARB if deemed appropriate. In addition, ICF will prepare progress reports and invoices with each milestone. Progress reports will be submitted electronically and will include a brief summary of project work conducted under each task, a list of deliverables, tasks anticipated during the next quarter, and any significant problems addressed during the quarter or to be addressed. The progress report will also quantify the percent of work accomplished to date and the percent of budget used to date, as well as the specific labor hours and dollars spent. Finally, the progress report will provide a

[3] ODS will include CFCs, HCFCs, and halons; other high-GWP gases will include HFCs, PFCs, NF_3, SF_6, HFEs, and/or PFPEs.

statement about any need to revise the schedule or budget class amounts to reflect changes needed over the existing schedule or budget.

Task 1: Literature Review

Following the Initial Project Meeting and approval of the project plan and schedule by the ARB, ICF will conduct a literature review under Task 1. The literature review will focus on identifying readily available information on (1) quantifying current and future stocks of high-GWP GHGs that may be available for destruction in California through 2020, and (2) developing a sound understanding of practice options for the recovery and destruction of such high-GWP GHGs, as well as the estimated costs and emissions associated with each option.

More specifically, ICF will conduct a review of the literature related to the recovery and destruction of high-GWP GHGs from (1) refrigerated appliances, (2) non-appliance foam, (3) fire extinguishers, and (4) other high-GWP GHGs (e.g., stored in bulk). To do so, ICF will gather information from industry sources, as well as local, state, and federal governments. ICF will collect information related to high-GWP gas stocks, banks, and emissions in California by product category; the age distribution of appliances, buildings, and other equipment that may contain high-GWP GHGs; and end-of-life management practices. ICF will seek publications and databases that describe current practices related to the inventories and uses of high-GWP GHGs in California, including:

- Any data already collected by ARB for this or other relevant project
- Reports from the Foams Technical Options Committee (under the Montreal Protocol) on high-GWP ODS substitutes
- Reports from the Association of Home Appliance Manufacturers (AHAM) on average equipment lifetime and quantities of refrigerant and foam
- Reports from the Technical University of Denmark, such as "Determination of the Fraction of Blowing Agent Released from Refrigerator/Freezer Foam After Decommissioning the Product" and "Attenuation of Alternative Blowing Agents in Landfills"
- Data from JACO Environmental and Appliance Recycling Centers of America, Inc. (ARCA) on the number of household appliances collected and treated in the state of California
- Census data on number of households in California, number of appliances in use, etc.
- Thomas Register and NAICS code data to develop industry data relevant to high-GWP GHG sectors
- Shipment data on domestic appliances and bulk ODS/high-GWP GHGs
- Other reports and studies related to recovery/destruction practices and technologies employed in other countries for managing high-GWP GHGs contained in bulk and/or equipment and products

Because the ICF Team is familiar with the above data sources and possesses technical expertise in the relevant areas, we can efficiently extract, analyze, and apply relevant information from available sources to develop emission inventories. Further, ICF's professional

Research Services Department provides ready access to government, research, university, law, and public libraries worldwide. The research department receives more than 200 general/technical journals and has access to more than 800 computerized databases.

To begin the literature review, ICF will review the extensive in-house data collected through previous research efforts, in order to identify and prioritize areas where further research is needed. After more than 20 years of work on issues related to banks and management of ozone depleting substances (ODS) and other high-GWP substances for the U.S. EPA, the United Nations Environment Programme (UNEP), the European Commission, and the World Bank, ICF's in-house resources are robust. For example, we maintain the U.S. EPA's Vintaging Model, which provides national estimates on foam banks, equipment retirement rates for refrigerated appliances, and refrigerant recovered from commercial equipment during service events for every year through 2030. In addition, in support of the U.S. EPA's voluntary Responsible Appliance Disposal (RAD) Program, we have developed information on the current state of appliance recycling efforts in the United States, as well detailed information on costs and benefits (i.e., emissions avoided) related to the collection and disposal of such equipment. ICF will build on this wealth of information by obtaining California-specific data from ARB and other organizations in California, as available.

In addition, ICF will conduct a literature review of data sources on lifecycle analysis. In particular, key data sources will include:

- ISO 14040 (2006): Lifecycle assessment -- Principles and framework
- ISO 14044 (2006): Lifecycle assessment -- Requirements and guidelines
- Sources of Lifecycle Inventory (LCI) data for the different components of the high-GWP material destruction cycle, namely:
  - Well to tank LCI data for the fuels involved in processing high-GWP materials (e.g., diesel for transport, electric power, and natural gas)
  - Emissions data from equipment involved in the fuel chain
- Documentation for the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET)[4] model and related studies
- ARB's Low Carbon Fuel Standard (LCFS) documents and databases
- Data sources of toxics that will allow for the speciation of toxic emission sources (e.g., fuel spillage, diesel exhaust)

The ICF Team already has extensive familiarity with the literature related to lifecycle analysis, including those sources listed above. Our team includes staff with wide-ranging lifecycle inventory experience, particularly related to GHG emissions, energy use, and the impact of waste disposal decisions on emission levels and energy consumption. Through our longstanding support of the Climate Change and Waste program of the US EPA, ICF has

[4] The GREET model from the Department of Energy's Argonne National Laboratory (ANL) is widely used for fuel cycle analyses. Life Cycle Associates has developed custom versions of the GREET model for many fuel cycle analysis applications.

developed lifecycle GHG and energy emission factors for more than 25 materials types and categories. In addition, ICF's subcontractor, Life Cycle Associates, has extensive experience in documenting the nuanced details of lifecycle energy inputs and emissions in the California context. For example, Life Cycle Associates staff were key contributors to the UC Berkeley Low Carbon Fuel Standard Technical and Policy Report and to several fuel cycle studies for the ARB. Life Cycle Associates has also developed custom versions of lifecycle analysis models, including the GREET Model. By building on this robust knowledge base, ICF will be able to cost-effectively conduct the literature search in a comprehensive manner, thereby ensuring that the project research plan and lifecycle analysis will be based on the best data possible.

Upon completion of the literature review, ICF will prepare a brief report summarizing the relevant literature and data sources. The literature review report will include a bibliography and will discuss the implications of available data and information for preparation of the project research plan (under Task 2), as well as the lifecycle and cost-benefit analyses (under Task 3.) The report for this task will be completed prior to the completion of Task 2.

Task 2: Refined Research Plan

Building on the information gathered under Task 1 and discussions with ARB, ICF will develop a refined research plan, including a detailed work plan and project schedule. The research plan will describe the methodology, data, and assumptions to be used in estimating current and future stocks of end-of-life appliances, non-appliance foams, fire extinguishers, and other stocks of high-GWP GHGs that may be made available for destruction through 2020. The forecasted inventories and material flows through 2020 will be based on sector growth rates and residence times, and will be elastic enough to account for variability.

In addition, the research plan will define the business-as-usual (BAU) and alternative recovery and destruction scenarios, as well as the specific steps needed to develop a robust lifecycle analysis (LCA) for each option. Based on the scenarios described in ARB's Technical Plan, ICF proposes to analyze the following BAU and alternative scenarios for insulating foams used in buildings and residential appliances (e.g., refrigerators/freezers):

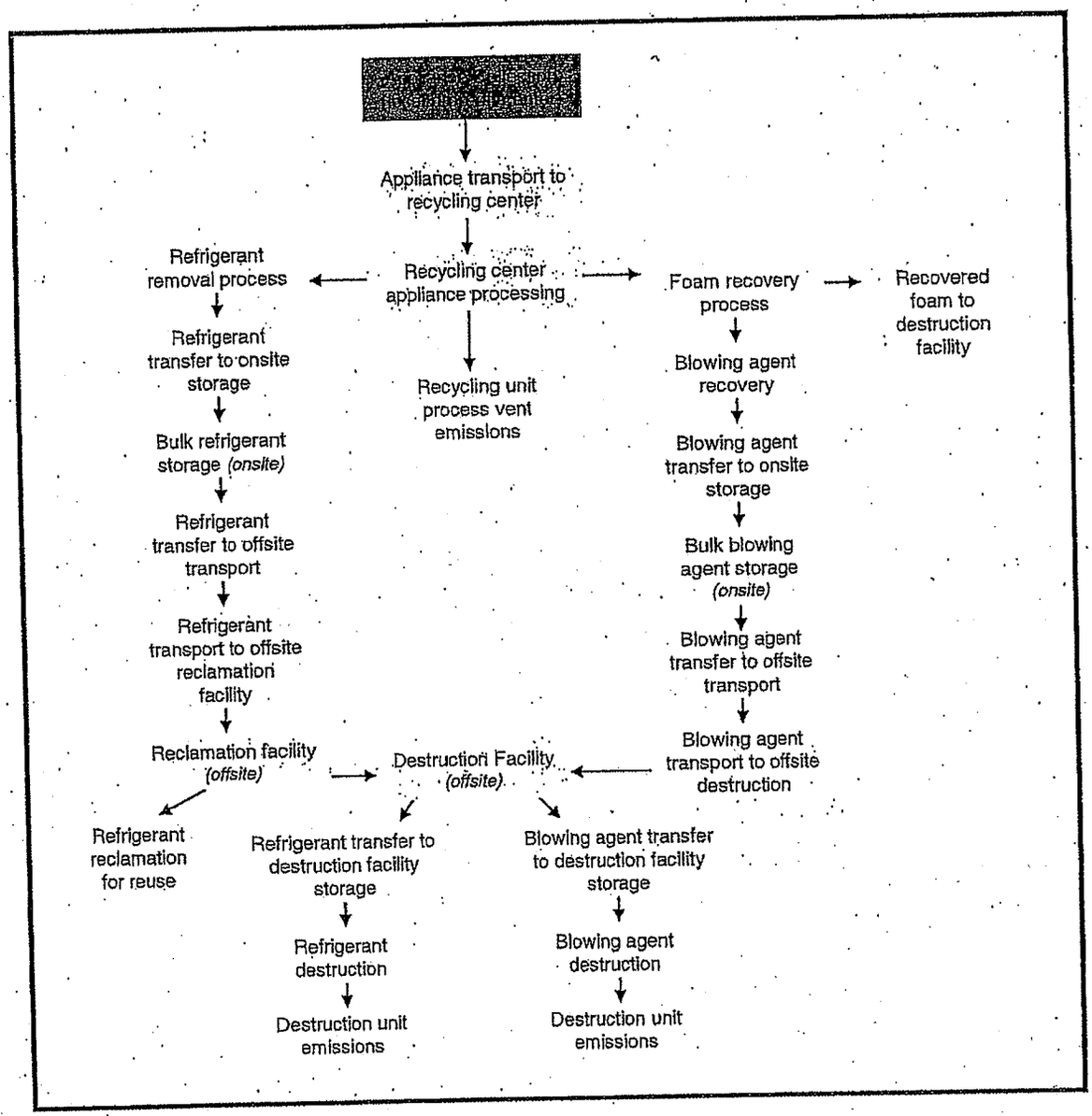
1) BAU: shredding and landfilling foams containing high-GWP blowing agents
2) Enhanced recovery of foams for direct (thermal) destruction.
3) Enhanced recovery of foam blowing agent for destruction or reclamation (reuse).

For the collection and treatment of high-GWP GHGs from domestic appliances, ICF will also explore the option of constructing one or more new facilities to process discarded appliances and recover high-GWP GHGs onsite. The various options for handling the recovered high-GWP GHGs at such facilities will also be explored, namely:

a. Reclamation offsite for resale;
b. Destruction onsite; or
c. Destruction offsite at in-state facilities.

A representative scenario flowchart for the operation of an appliance collection/recycling facility and related processes is shown in Exhibit 4-1. The figure provides an example of the types of activities and processes effecting the ODS or high-GWP GHG that would be evaluated for a lifecycle analysis of an appliance collection/recycling facility scenario.

Exhibit 4-1: Sample Flowchart for the Operation of an Appliance Collection/Recycling Facility and Related Processes



In addition, ICF will explore all reasonable options for destroying bulk high-GWP GHGs recovered from other types of equipment, products, and/or stockpiles. Specifically, ICF's research plan will describe the data, methodologies, and assumptions to be used to develop estimates of costs and emissions savings for the following scenarios:

1) Utilization of mobile processing and/or destruction systems for recovered high-GWP GHGs;
2) Utilization of in-state facilities (e.g., cement kilns, RCRA hazardous waste incinerators) to destroy recovered high-GWP GHGs; and
3) Shipment of the recovered high-GWP GHGs to out-of-state facilities for destruction.

For each scenario, ICF will also consider a range of "processing strategies" to collect the high-GWP GHGs—be it by truck, rail, or ship. Likewise, the types of destruction technologies will also be important to define; for example, will destruction be performed in a cement kiln or municipal solid waste incinerator? Will the incinerator require additional fuel input?

Creative options to augment the emission reduction potential of scenarios may also be incorporated into the refined research plan. For example, specific actions to enhance the collection rate of old appliances or fire extinguishers may be included in one or more of the scenarios—such as consumer outreach/marketing schemes or even mail-in rebates. Likewise, depending on the level of emissions, abatement potential, and level of ARB interest in the options, additional scenarios may be developed to target the collection of high-GWP GHGs from certain sectors, such NF_3 from the semiconductor manufacturing sector, SF_6 from the electric power industry, or HFEs/PFPEs from the metal and precision cleaning industries.

In defining the various scenarios to be explored, ICF will focus on those that are most viable—i.e., those that can achieve significant GHG emission reductions at a reasonable economic cost; and those that are likely to be most effective—i.e., those that wouldn't be occurring already as common practice (such as existing initiatives within the semiconductor industry). Thus, to the extent possible, each processing option will be assessed for technical and economic viability, as well as likely emission benefits. To do so, ICF will conduct a screening analysis during the development of the refined research plan to assess which combination of gases, sectors, and scenarios may offer viable emission reduction opportunities. In particular, ICF will start by reviewing the baseline high-GWP GHGs on a GWP-adjusted tonnage basis, to determine which may have existing and/or forecasted inventories significant enough to substantively affect the lifecycle cost-benefit analysis. For example, it is likely that baseline emissions of SF_6 from the electric power sector may not be very significant, given the highly specialized nature of this sector and the fact that most companies in this sector adhere to exacting industry standards that help ensure that best environmental practices are followed. Within the available budget and considering ARB priorities, ICF will work to prioritize full lifecycle analyses for those options that pass the initial screening.

Once BAU and alternative recovery/destruction scenarios are defined for the LCA, ICF will consider the methodologies and assumptions to be described in the refined research plan related to:

- Identification of system boundaries for lifecycle analyses, including "inputs" and "outputs" for each scenario;

- Estimation of forecasted lifecycle emissions of ODS and high-GWP GHGs under each scenario;
- Estimation of forecasted lifecycle toxic and criteria air pollutant emissions under each scenario; and
- Development of uncertainty analyses for estimating inventories of banked ODS and high-GWP GHGs and material flows.

Each of these elements will be broadly defined in the research plan, with specifics to be elaborated under Task 3. ICF anticipates conducting the lifecycle analysis in accordance with ISO Standards 14040 and 14044 for lifecycle analysis using a "best effort" approach. ISO Standards for lifecycle analysis will be applied to this project to the extent feasible given available data. The project research plan will incorporate the four basic phases of lifecycle analysis identified in the ISO Standards:

- Goals and Scope Definition;
- Inventory Analysis;
- Impact Assessment; and
- Interpretation.

Task 3: Data Analysis

Under this task, ICF will develop the BAU baseline and conduct the detailed lifecycle analyses for the BAU scenario and the various high-GWP GHG recovery/destruction scenarios identified in the refined research plan under Task 2. The lifecycle analyses will estimate the costs and benefits associated with each scenario for each year to 2020. ICF assumes that the destruction processes identified in the recovery/destruction options for ODS will be based on the destruction technologies approved under the Montreal Protocol.

ICF will prepare the BAU scenario using existing information collected by ARB, published California GHG emission estimates, default emission factors, and information collected under Task 1. The BAU scenario will assume that current practices continue, i.e., that no actions are taken specifically to reduce high-GWP GHG emissions. Thus, the full impact of any reduction scenario can be assessed. The BAU will be estimated in a modeling framework that will be flexible to allow for modification of specific parameters (e.g., loss at equipment retirement, increased recovery) to correspond to each scenario. ICF proposes to create the BAU and alternate scenarios in an Excel-based platform, which will be fully documented and transparent.

Lifecycle costs addressed in the cost-benefit analysis will include costs associated with collection, recovery, and destruction of the ODS/high-GWP GHGs under the BAU and alternative scenarios. For example, ICF will assess the costs of collecting and transporting used appliances; leasing or purchasing and operating mobile equipment; constructing and operating appliance recycling and destruction facilities; and operating existing infrastructure (e.g., municipal solid waste incinerators, cement kilns, hazardous waste incinerators) for the destruction of high-GWP GHGs. The lifecycle cost analysis will also include the costs of control and disposal of byproducts of destruction processes and will determine the incremental nature of such practices (e.g., existing requirements under Federal or state legislation for treatment of certain waste streams may mean that they are part of the baseline and will identified as such in analysis of options).

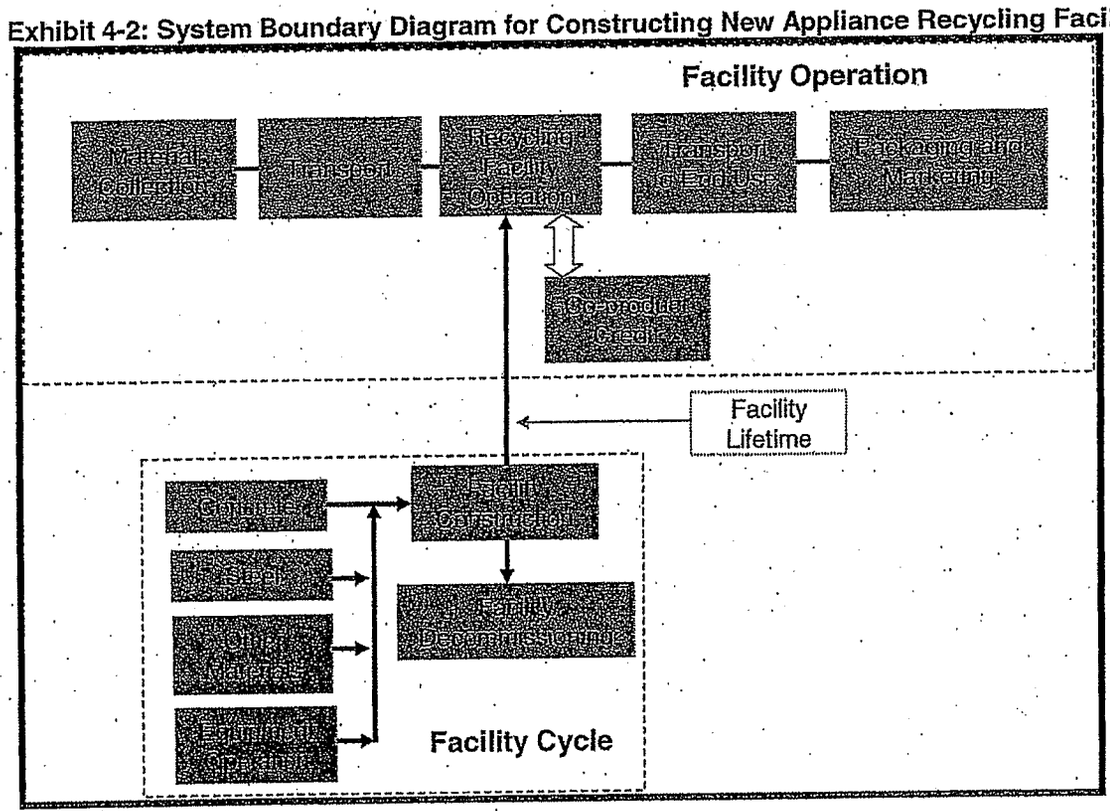
To more specifically describe ICF's approach for tackling the data analysis, Task 3 has been divided into five subtasks. Task 3.1 is the identification of system boundaries; Task 3.2 is the development of lifecycle inventory data; Task 3.3 is the lifecycle analysis and the assessment of lifecycle impacts; Task 3.4 is the cost-benefit analysis; and Task 3.5 is the preparation the data analysis report.

Task 3.1: Identify System Boundaries

Under this subtask, ICF will define system boundaries for each scenario for which a lifecycle analysis will be conducted. The system boundary will clearly define (1) the specific systems and activities covered, (2) the lifecycle analysis criteria, and (3) the geographic scope.

In defining the specific systems and activities of the lifecycle analyses, the ICF Team will identify which direct and indirect activities are within the scope of each recovery/destruction scenario to be reviewed, and which are considered to be beyond the project scope. For each scenario, ICF will develop a diagram illustrating the system boundaries, such as the example shown in Exhibit 4-2 for the construction of a new appliance recycling facility. As shown, the sample system boundary for the new appliance recycling facility includes not just the activities that fall within the purview of operating the facility, but also those related to the facility cycle—i.e., from the construction to the decommissioning of the facility itself.

Exhibit 4-2: System Boundary Diagram for Constructing New Appliance Recycling Facility



For each scenario, the "inputs" and "outputs" of the system boundaries will be defined. Inputs may include the consumption of fuels—such as transportation diesel fuel, natural gas for thermal destruction processes—purchased electricity, and raw materials. Outputs may include:

- Emissions of diesel particulate matter (DPM);
- Emissions of polycyclic aromatic hydrocarbons (PAH);
- Emissions of polychlorinated dioxins and furans (PCDD/PCDF);
- Emissions of sulfur oxides and nitrogen oxides;
- Emissions of ODS, GHGs, and high-GWP GHGs associated with the BAU scenario and other scenarios (e.g., high-GWP gas emissions from shredding and landfilling of foams); and
- Emissions of high-GWP GHGs and products of incomplete combustion (PICs) from thermal destruction processes.

ICF is currently performing cutting-edge research in support of the US EPA related to the identification of PICs associated with thermal destruction of HCFCs and halons; we anticipate applying lessons learned from this research to this lifecycle analysis. ICF also anticipates that other completed and ongoing studies conducted by ARB (e.g., Study on Foam Banks and Emissions from Foams) will be coordinated in this proposed lifecycle analysis.

In defining the lifecycle analysis criteria, ICF will explicitly state the GHGs and toxic and criteria pollutants to be considered. Consideration of toxic/criteria pollutants will include an assessment of toxics speciation based on ARB data and the application of relevant models (e.g., the EMission FACtor [EMFAC] model for mobile source emission rates). The ICF Team will examine the likely uncertainties in lifecycle impacts across the range of criteria (i.e., emissions of GHGs, toxics, etc.) in order to ensure that the scenarios represent the true range of environmental risks. Likewise, the system boundaries will define the limits of the lifecycle analysis, including:

- De minimus levels for lifecycle analysis criteria;
- Grouping of criteria pollutant and air toxics emissions (e.g., California urban area);
- Regional specific lifecycle factors (power generation mix, natural gas supply, etc.);
- Treatment of co-products (system expansion, substitution, allocation);
- Truncation of lifecycle analysis; and
- Approach to mitigate market effects (e.g., uncertainty analysis to examine second order market effects).

Finally, the ICF Team will work with ARB to define the appropriate system boundaries for *regional* emissions. ICF proposes that the regional definition be as follows:

- California non-attainment areas
- Rest of California
- Rest of US
- Rest of world

The regional definition of California non-attainment areas would allow for the aggregation of emissions in a manner that is consistent with California air pollution emission inventories.

Another important element of the system boundary definition is the treatment of regional boundaries for assessing criteria pollutant and toxic air contaminant emissions. In other words, the analysis must consider *where* emissions occur. But estimates of the global criteria pollutant emissions from lifecycle models do not describe the regional impact (for example NO_x in California non-attainment areas). Furthermore, many pollutant emissions occur in regions (e.g., open ocean) where the environmental impact may be different than in urban areas. The definition of boundaries will also need to consider the extent to which transport emissions are to be included in California urban areas (for example 100 nautical miles for marine vessel transport). The ICF Team proposes to track emissions by region by grouping the LCI values in a database format. The region where emissions occur would be identified for all of the fuel cycle components in order to allow for a grouping by region. ICF proposes to group transportation emissions based on the distanced traveled in each region. Such groupings are consistent with prior ARB lifecycle studies.[5]

Task 3.2: Develop Lifecycle Inventory Data

Under Task 3.2, a comprehensive lifecycle inventory (LCI) of relevant inputs and outputs of each scenario will be developed. For each scenario, LCI data will be developed based on the defined system boundary, and regional specific parameters and limits of the analysis. For each scenario, the LCI data will be organized by lifecycle components, and will include direct and indirect emissions of ODS and high-GWP GHGs, as well as other GHGs, and toxic and criteria pollutants. For example, direct emissions will include combustion emissions from thermal destruction processes, while indirect emissions will include combustion emissions associated with purchased electricity.

ICF will estimate direct emissions of high-GWP GHGs and other GHGs (e.g., CO_2, CH_4) associated with systems and activities for the BAU and other scenarios in units of CO_2 equivalents (CO_2E) and in metric tons. For each scenario, ICF will present direct ODS and high-GWP gas emissions into functional units, such as grams of emissions per ton of material processed or percent of material emitted annually. ICF has conducted extensive research to compile emission factors for high-GWP GHG systems, including:

- Cylinder leakage
- Storage tank leakage
- Emissions from equipment heels
- Emissions from transfers from pressurized containers
- Emissions from transfers from non-pressurized containers
- Bulk high-GWP GHG destruction unit efficiency
- Management of foams
- Landfill disposal of foams
- Thermal destruction of foams

[5] Montano, M., S. Unnasch, P. Franklin, G. Nowell, C. Martin, and E. Craig, "Reclamation of Automotive Batteries: Assessment of Health Impacts and Recycling Technology, Task 1 — Assessment of Recycling Technologies," prepared for ARB under Contract A93-323, March 1995; Unnasch, S., S. Huey, and L. Browning, "Evaluation of Fuel Cycle Emissions on a Reactivity Basis," prepared for ARB, September 1996.

For example, ICF anticipates applying an emissions model based on 2006 IPCC Guidelines to activity data to estimate high-GWP GHG emissions from production, use, and management of foams. The general approach to estimating emissions from foams includes developing estimates for:

- *Market Size*: the size of the foam manufacturing industry in California, as well as the quantity of foam already present within the state (i.e., the bank);
- *Quantity of Chemical (blowing agent)*: the approximate amount of blowing agent used in manufactured products and the overall quantities of such products;
- *Manufacturing, Lifetime, and Disposal Losses*: these could be estimated using default assumptions from published data sources such as those presented in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories[6] or using other available data sources;
- *Post-Disposal Losses*: emissions that occur in the years after the foam is disposed (e.g., landfilled) could be estimated using default assumptions from published data sources such as those presented in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories or data from the Technical University of Denmark.[7]

ICF will also estimate direct toxic and criteria pollutant air emissions from high-GWP GHG systems and activities for each scenario in metric tons. In doing so, ICF will rely on a wide range of sources for emission factors. For example, ICF anticipates applying TEAP reported emissions factors for toxic and criteria pollutant emissions from the destruction of ODS and high-GWP GHGs, by specific technology type, as presented in Exhibit 4-3.

Exhibit 4-3: TEAP Recommended Emission Limits for ODS Destruction

Combustor Type	DRE	PCDD/Fs	HCl/Cl$_2$	HF	HBr/Br$_2$	PM	CO	ODS Type
	(%)	(ng/m^3)	(mg/m^3)					
All ODS Destruction Technologies	99.99	0.2	100	5	5	50	100	Any

[a] Emission limits are expressed as mass per dry cubic meter of flue gas at 0°C and 101.3 kPa corrected to 11 percent oxygen.

Next, ICF will gather emission data associated with the material "processing steps" for each scenario, including:

- Stationary combustion – diesel fuel, natural gas, bunker fuel
- Fork lifts – diesel fuel
- Trucks – diesel fuel
- Rail car – diesel fuel
- Marine vessel – bunker fuel
- Plastics, other material inputs

[6] http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm.

[7] Including: *Fate of Fluorocarbons Released from Polyurethane Insulation Foam Waste Disposed of in an Automotive Shredder Residue Landfill Cell* by Kjeldsen et al. (2006) and *Disposal of Refrigerators-Freezers in the US: State of the Practice; Determination of Content of Blowing Agent in Pre- and Post-Shredded Foam and Modeling* by Kjeldsen et al. (2005).

The ICF Team will assemble an LCI "vector" that describes the lifecycle criteria (pollutants) for each component in the fuel cycle. ICF will apply emission factors that are consistent with those already used in California, including factors for trucks, off road equipment, power plants, and others. For example, Exhibit 4-4 shows the fuel cycle and direct emissions for diesel fuel and electric power; these emission factors were derived from the GREET model with California-specific inputs. The full LCI vector will be combined with truck emission factors from EMFAC. Toxics emissions will be based on speciated hydrocarbons from ARB's speciate database.

Exhibit 4-4: Example fuel cycle and direct emissions from diesel and electric power

Fuel/ Emission Type	Diesel	Electric Power
Fuel Cycle Emissions (g/gal)		
CO_2	14.15	93.50
CH_4	0.10	0.41
N_2O	0.00	0.00
GHGs (weighted)	16.42	103.64
VOC (total)	10.66	10.19
CO (total)	16.30	25.63
NO_x (total)	54.11	8.76
PM_{10} (total)	3.86	1.69
$PM_{2.5}$ (total)	2.96	2.10
SO_x (total)	16.04	16.01
VOC (urban)	3.47	0.21
CO (urban)	0.29	12.91
NO_x (urban)	0.79	0.91
PM_{10} Exh (urban)	0.03	1.27
$PM_{2.5}$ Exh (urban)	0.03	1.28
SOx (urban)	0.03	0.00
Benzene (urban)	0.001	0.000
1-3 Butadiene (urban)	0.000	0.000
Formaldehyde (urban)	0.008	0.016
Acetaldehyde (urban)	0.004	0.000
Diesel PM (urban)	0.025	0
Direct Combustion Emissions (g/gal)		
Carbon in Fuel	73.00	0
Vehicle Exhaust	From EMFAC	Included in fuel cycle

Task 3.3 Lifecycle Analysis and Lifecycle Impact Assessment

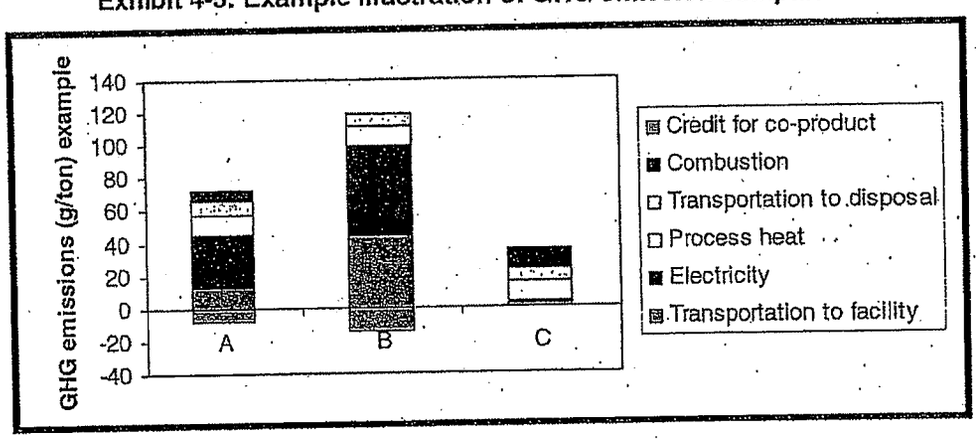
Lifecycle analysis will be conducted for each scenario, based on the boundary conditions identified in Task 3.1 by applying the lifecycle data developed under Task 3.2. ICF will combine the LCI data to build the lifecycle for each scenario. First the steps in the lifecycle will be determined for each scenario. Process energy inputs, fugitive loss rates, and transportation distances will provide the calculation input for the lifecycle. Each lifecycle input will be measured based on a functional unit of processed material (e.g., kWh/ton of foam). The emissions will then be summed to represent the lifecycle emissions for each scenario.

Key factors that enter into the lifecycle analysis will include:

- Coproduct credits
- Transportation distances
- Cargo capacity for trucks/rail
- Process energy requirements
- Fate of materials in land fill

Lifecycle impacts will be assessed for each scenario and comparative analysis will be conducted to assess which scenarios would result in lower or higher lifecycle impacts than the BAU scenario. As stated, lifecycle impacts will be evaluated in terms of GHG emissions and toxic and criteria pollutant emissions. Exhibit 4-5 presents a generic illustration of one method of depicting GHG emission comparisons across several different scenarios.

Exhibit 4-5: Example illustration of GHG emission comparison



Task 3.4: Cost-Benefit Analysis

ICF will develop a cost-benefit analysis for each scenario. It is assumed that the analysis will consider the following costs:

- Construction, operation, and decommissioning of fixed appliance recycling facilities;
- Construction, operation, and decommissioning of thermal destruction technologies;
- Procurement and operation of mobile destruction units;

- Transportation and destruction of materials; and
- Destruction of high-GWP GHGs.

In developing the above costs, ICF will consider the cost of construction and operating labor and materials, purchased electricity, operating and transportation fuels, purchased or leased equipment, third-party costs (e.g., for offsite high-GWP GHG destruction) and other related cost elements. Recognizing that many of the specific costs of facilities are often confidential, ICF will apply assumptions as necessary based on experience performing similar work, and fully document all assumptions made. For existing operations that would be utilized within any option (e.g., existing destruction facilities), the incremental difference in costs due to the implementation of the ODS or high-GWP destruction activities would be analyzed. Costs will be analyzed using a discounted cash flow analysis and presented using a common basis, such as estimating the costs (or savings) per ton of carbon equivalents reduced.

ICF has developed in-house expertise and data sources to help estimate lifecycle costs of building and operating appliance recycling facilities, mobile and fixed high-GWP GHG destruction facilities, and associated activities (e.g., transportation). Specifically, ICF has conducted previous projects for the US EPA, UNEP, and others for which we have conducted site visits to and collected data from appliance recycling facilities, high-GWP GHG destruction facilities, solvent recovery facilities, and chemical conversion facilities. From these projects, ICF has developed robust data on the capital costs of various destruction technologies as well as the costs to establish and operate both small- and large-scale appliance recycling facilities.

The ICF Team also has specific expertise in estimating energy systems and transportation costs, and has conducted numerous cost estimation projects, including projects to support ARB in the development of the Low Carbon Fuel Standard (LCFS) and other initiatives. Indeed, Life Cycle Associates has conducted a series of "well to wheels" analyses for production and use of conventional and alternative transportation fuels, including greenhouse gas emissions estimates and lifecycle cost estimates. Life Cycle Associates also conducted an economic analysis study for the State of Illinois of the capacity potential, cost, and deployment potential of biomass and coal gasification electricity generation, projected to the year 2020.

The benefits will be measured in terms of *avoided emissions* of ODS and GHGs, and associated changes in criteria pollutant and toxics emissions—based on the lifecycle emissions estimated for each scenario relative to the baseline. Because the purpose of the analysis is, at its core, to evaluate these options in the context of AB 32, evaluating the impact on GWP-weighted emissions of ODS or GHGs will be paramount, and costs will primarily be presented in terms of carbon dioxide equivalent emissions avoided. Co-benefits or dis-benefits of each option in terms of other air or waste emissions will be tabulated as additional information that ARB can use to evaluate the full impact of any option examined.

Task 3.5 Data Analysis Report

Finally, under Task 3.5 ICF will prepare a draft report summarizing the baseline forecast high-GWP GHG emission through 2020, together with some information about the related uncertainty. In addition, the report will present the results of the lifecycle analysis for the BAU and alternative recovery/destruction scenarios. Such results will be presented in detailed tables/spreadsheets denoting lifecycle emissions and costs—by scenario and year—associated with each step of the collection, recovery, transport, and destruction of high-GWP GHGs. Because the draft and final project reports will be prepared under Task 4, ICF envisions the

report submitted under Task 3.5 to consist mainly of data analysis, in the form of spreadsheets and summary tables or figures. The final report under Task 3 will be presented to the ARB Contract Manager prior to the completion of Task 4.

Task 4: Draft and Final Reports

Under Task 4 ICF will prepare a draft report describing data and data sources, research methodology, and analytical results for work conducted under all previous tasks. The draft report will summarize the lifecycle analysis results in terms of GHG emissions in units of CO_2E, monetary costs, monetary benefits, and toxic and criteria air emissions (in units of metric tons) and generation of other toxic emissions or hazardous wastes for the BAU and other scenarios analyzed. The draft deliverable under Task 4 will incorporate the deliverables under Tasks 1, 2, and 3 described above. The draft deliverable will also include a figure summarizing the CO_2E emissions for the BAU scenario and forecasted reductions in CO_2E emissions for the various scenarios analyzed each year to 2020. The figure will illustrate error bars and uncertainties for each scenario analysis. ICF will deliver 20 bound copies of a draft final report and one electronic copy to the ARB for review six months prior to the contract termination date. This report will confirm to the Research Contract Final Report Format, Appendix VII. Based on comments from ARB, ICF will subsequently prepare a final report, which will be subject to formal review by the Research Screening Committee.

Task 5: Technical Seminar

Within two months of the formal approval of the final report, ICF will present a technical seminar to ARB and other interested parties at ARB. The scope of the technical seminar will cover the entire project including purpose, methodology, and results. ICF will prepare PowerPoint presentation materials summarizing the analysis and deliver the presentation in Sacramento. For budgeting purposes, ICF proposes to send the Project Manager and one other team member, and to teleconference other team members if possible. ICF proposes that the ICF Project Manager will be the lead presenter of the Technical Seminar.

Schedule

The ICF Team proposes to perform this project as outlined in the approaches for Tasks 0 through 5, above, over a period of 12 months; the following schedule provides our suggested timeline for the project. The schedule assumes that the draft report will be delivered 6 months after the beginning of the one-year period of performance, and that the comment period for ARB and related stakeholders will last for up to 6 weeks; ICF will prepare the final report based on input, revising analyses as necessary, within 2 months of receipt of comments. ICF allows for 2 weeks for ARB to formally approve the final report, and the technical presentation will occur within 2 months of the formal approval.

As indicated above, our first objective will be to discuss this schedule, revise it based on communication with ARB staff in a kick-off meeting, which ICF will be available to attend at ARB's Sacramento offices. To afford the necessary assurance that the project is moving on schedule, regular updates via teleconference will be scheduled, in addition to regular e-mail correspondence. Through the course of the work, ICF also will update ARB on the progress of the work on a quarterly basis, with the first progress report delivered within three months of the date of the signing of the contract.

Milestone/Deliverable	Proposed Date[a]	Proposed Hours
Task 0: Project Management and Kick-Off		**94**
Kick-off Meeting at ARB's offices in Sacramento	2	20
Telephone Conferences with ARB Staff	2 through 52	44
Progress Reports and Invoices	2 through 52	30
Task 1: Literature Review		**130**
Literature Review Summary Report	6	130
Task 2: Refined Research Plan		**420**
Refined Research Plan	10	420
Task 3: Data Analysis		**1391**
Data Analysis Report	22	1391
Task 4: Draft and Final Reports		**452**
Draft Report	26	372
Final Report	40	80
Task 5: Technical Seminar		**92**
Technical Seminar	50	92

[a] *Weeks from contract execution.*

5 Personnel

The ICF Team consists of highly qualified personnel who collectively have over 200 years of experience focused on high-GWP gases, lifecycle analyses, and estimating emissions and emission projections for recovery and destruction scenarios. The personnel qualifications and experience table (below) presents years of experience and areas of expertise for ICF staff and the sub-contractors. We follow with a presentation of the ICF Team's roles and qualifications by individual.

			High-GWP Sectors Expertise				Experience in Relevant Areas		
Name	Years Experience	Agreement Hours	Foams	Refrigeration	Banks of ODS	End -of-life Options	Lifecycle Analyses	ODS Collection and Destruction	CHG Inventory Development
Wagner, Mark	25	108	•	•	•	•	•	•	•
Mathis, Pamela	8	165	•	•	•	•	•	•	•
Van Pelt, Marian	10	126	•	•	•	•	•	•	•
Rotherham, Duncan	10	35	•	•	•	•		•	•
Facanha, Christiano	10	65					•		•
Cohen, Jonathan	25	60							•
Lanza, Robert	25	111	•	•	•	•	•	•	•
Russell, Robert	20	39	•	•	•	•	•	•	•
Groth, Philip	6	108	•	•	•		•		•
Moffroid, Katrin	8	230	•	•					•
Kyle, Jessica	4	78	•	•	•	•		•	
Kumar, Pankaj	5	58			•	•	•	•	•
Menassian, Sarah	1	430		•	•	•			•
Kessler, Tristan	2	310	•	•	•	•			•
Li, Sandy		24							
Unnasch, Stefan (Life Cycle Associates)	20	204					•		
Plevin, Rich (Life Cycle Associates)	4	216					•		
Riffel, Brent (SDV-SCC)	6	200					•		
Ewing, Robert (SDV-SCC)	20	212					•		

Mark Wagner will serve as the Engagement Leader and will be responsible for overseeing all tasks and ensuring that work is performed to the highest quality and delivered on time and within budget. Mr. Wagner is an ICF Senior Vice President with 25 years of experience in the fields of technical, economic, and regulatory analysis for the US Environmental Protection Agency, the European Commission, the World Bank, the United Nations Environment Programme, the Australian Greenhouse Office, the Global Environment Facility, and the US Food and Drug Administration. For these initiatives, he provides technical and managerial oversight in the areas of risk assessment and toxicity screening for chemicals, emission projections; health effects and atmospheric modeling; regulatory, technical, economic, and cost/benefit analyses; and market characterizations to support rulemaking activities.

Mr. Wagner is responsible for management of ICF's 5-year, $10 million, mission support contract on Implementation of Programs for Stratospheric Ozone Protection for US EPA's Stratospheric Protection Division with a broad scope of work to support the phaseout of ozone depleting substance (ODS) under the Clean Air Act and its Amendments. Under this contract, he manages the modeling of US ODS and ODS substitutes emissions to support the Vintaging Model. The project is a bottom-up predictive model based on historical emissions data and actual industry data that predicts future emissions for various ozone depleting substances and ODS substitutes, including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), hydrocarbons, and sulfur hexafluoride (SF_6).

Mr. Wagner provides oversight for projects involving the management of ODS stockpiles, including U.S. EPA's Responsible Appliance Disposal Program and GreenChill Program. Mr. Wagner has also provided oversight for multiple destruction projects including (1) the preparation of a report for the U.S. EPA Significant New Alternatives Policy (SNAP) Program on substitutes for ODS and on available destruction technologies for ODS, including rotary kiln incineration, thermal destruction in cement kilns and lime kilns, and non-thermal chemical treatment technologies and (2) for the UN Multilateral Fund, reviewing the systems and procedures in place to collect and destroy unwanted ODS contained in household appliances and in bulk in order to provide guidance on how best to establish appropriate management systems for the treatment of unwanted ODS in developing countries. Additionally, Mr. Wagner provided oversight for a project developed for US EPA to provide carbon credits under the Chicago Climate Exchange (CCX) to industries for the destruction of ODS—in lieu of indefinite storage or venting. The project was accepted for trading in the carbon markets as the world's first ODS project offset type in 2007 and companies can receive carbon credits for the destruction of their ODS. Mr. Wagner holds S.B. degrees in both Chemistry and Biology from the Massachusetts Institute of Technology.

Pamela Mathis will serve as the Project Manager for this Project. Ms. Mathis, a Project Manager at ICF International, works on economic and scientific issues related to international stratospheric ozone depletion and global climate change. She is experienced in the management of ODS stockpiles and ODS destruction. She is also experienced in developing emissions inventories, collecting and analyzing data, writing technical and scientific documents, building and running models, conducting research and evaluations, and writing communications and outreach pieces. While at ICF, Ms. Mathis has become a sector expert in refrigeration/air-conditioning and fire extinguishing, as well as other "Montreal Protocol" sectors that have historically relied on using ozone depleting substances and have transitioned to using chemicals with high global warming potentials (high-GWP). Ms. Mathis currently manages EPA's Responsible Appliance Disposal Program, a new voluntary program for municipalities, retailers, manufacturers, and utilities to promote the responsible disposal of refrigerated appliances, including refrigerators/freezers, window air-conditioning units, and dehumidifiers. The program seeks to ensure the proper disposal/recycling of ozone-depleting refrigerant and foam, greenhouse gas refrigerant, and hazardous materials, including PCBs, mercury, and used oil. As part of this project, Ms. Mathis visited the two major appliance recycling facilities in California. She is also managing a project for the UN Multilateral Fund reviewing the systems and procedures in place to collect and destroy unwanted ODS contained in household appliances and in bulk in order to provide guidance on how best to establish appropriate management systems for the treatment of unwanted ODS in developing countries. As part of

this project, Ms. Mathis visited appliance recycling facilities, refrigerant reclamation facilities, and ODS/high-GWP GHG destruction facilities in Australia and Japan.

Ms. Mathis has played leading roles in the development and maintenance of the refrigeration/Air-conditioning and fire sectors of the U.S. EPA's Vintaging Model to inventory ODS and high-GWP gases in the United States, as well as analyses for both domestic and international marginal abatement curves (MACs) for non-CO_2 high-GWP gases, including those developed for the California Energy Commission (CEC), the U.S. EPA, the Australian Greenhouse Office (AGO), and the International Energy Agency (IEA). She has also conducted countless other analyses related to the refrigeration/AC and fire protection sectors for clients worldwide, including the European Commission (EC), the World Bank, the Global Environment Facility (GEF), and the U.S. EPA. This work has included the preparation of market characterizations, substitutes assessments, emission projections, as well as cost-/benefit and small business analyses related to the development and implementation of regulations to minimize emissions of ODS and their substitutes.

Marian Van Pelt, a Principal at ICF International, has 14 years of experience conducting research, performing environmental analyses, supporting national policy, and developing models related to climate change and stratospheric ozone depletion. She has provided technical support to the US EPA in the areas of emissions modeling, developing emission estimates for the US GHG inventory, tracking emissions of ozone-depleting chemicals, and developing marginal abatement cost curves. Since 1999, Ms. Van Pelt has been the lead coordinator in support of the development of EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks, responsible for generating emission estimates from numerous industrial sources, in addition to aggregating all the data and creating the final Inventory document. She has 10 years of experience managing EPA's Vintaging Model, which is used to develop the EPA inventory of HFCs, PFCs, SF_6 and ODS. Ms. Van Pelt is an internationally recognized expert in industrial process GHG emissions and in overall GHG emission inventories. She has also conducted a variety of national and international analyses focused on GHG emission inventories, and evaluating the emissions and reduction opportunities of engineered chemicals (HFCs, HFEs, PFCs, and SF_6). Ms. Van Pelt prepared marginal abatement cost analyses of all high-GWP gases in the U.S., internationally, and for the state of California.

Duncan Rotherham will serve as a technical expert for this analysis. Mr. Rotherham is a Principal with ICF International working in the Energy Group's Energy Markets Practice. He has 10 years experience providing a wide range of services to the North American and International oil and gas, electricity/gas utility, aluminum and metals, forest products, manufacturing, and chemical sectors. Mr. Rotherham has supported DuPont since 1999 in their high-GWP abatement projects in the areas of N_2O from Adipic and Nitric Acid facilities and HFC-23 from HCFC-22 production facilities. Internationally, he has supported the development of Project Design Documents for the Adipic (2) and Nitric N_2O (3) abatement project developers in the Clean Development Mechanism and Joint Implementation. All these projects required a detailed understanding of the production process, data management and abatement technologies. Mr. Rotherham has worked with over 40 companies to assess current emissions management systems, identify gaps, develop robust inventories, implement transparent operating procedures, and tools. Mr. Rotherham has also assessed emission abatement options, developed coordinated multi-pollutant emission reduction strategies, supported the development of marginal abatement cost curves (MACs), and quantified carbon risk. Mr. Rotherham leads ICF International Canada Inc's audit business and has carried out over 30+

audits of emission reduction / offset projects in the US and Canada. Specifically, he has carried out audit in the landfill gas sector (CH_4 capture and combustion), geological sequestration (acid gas capture and enhanced oil recovery), renewable power, as well as energy efficiency and transportation. Duncan Rotherham is a lead auditor with extensive auditing experience in the private sector. He has designed, built, deployed and audited environmental management systems and processes for many major corporations including Sunoco, Ontario Hydro Nuclear, Ontario Power Generation, SaskPower, Manitoba Hydro, Tembec and CXY Chemicals.

Cristiano Facanha, PhD will serve as an expert on the process of lifecycle assessment (LCA). Dr. Facanha is a transportation engineer with 10 years of experience in the transportation industry. During his Ph.D. program at the University of California at Berkeley, Dr. Facanha completed an LCA of transportation systems. His research concentrated on both process-based LCA and economic input-output analysis-based LCA to evaluate and quantify the environmental effects of vehicles, transportation infrastructure, and fuels. He has experience with many LCA tools, such as GREET, Gabi, and EIO-LCA. Dr. Facanha recently assisted in the review process of the TIAX's Well-to-Wheels report to the California Energy Commission, which evaluated the greenhouse gas emissions from several vehicle technologies and fuels. His current work at ICF also involves the development of operational and technological strategies to prevent and mitigate environmental impacts of freight transportation.

Jonathan Cohen, PhD will serve as the senior statistician and uncertainty expert for this analysis. Dr. Cohen has 25 years of experience in the field of statistical theory and its applications to the statistical data analysis of environmental land, air, and water quality and emissions data. He uses these skills in the design and analysis of experiments and sample surveys, general linear models, database management, applied probability, and statistical simulation. Dr. Cohen will oversee the data analysis in Tasks 3 and 4.

Mr. Robert Lanza, P.E. will serve as a technical specialist and will be responsible for leading the incineration and destruction analyses. Mr. Lanza is a Principal Chemical Engineer with more than 25 years of experience in conducting environmental assessments of private sector and government facilities; providing regulatory development and environmental program management support to Federal agencies, and providing assistance in preparing technical analyses and carbon storage and emission calculations for the Inventory of U.S. Greenhouse Gas Emissions and Sinks for the EPA. Mr. Lanza is Lead Author of the Intergovernmental Panel on Climate Change (IPCC) 2006 Greenhouse Gas Inventory Guidelines (2006 GL) for Petrochemical and Carbon Black Production and a Contributing Author to the 2006 GL for Iron and Steel and Metallurgical Coke Production. Mr. Lanza is also providing technical support to EPA for assessment of ozone-depleting substance destruction and for lifecycle analysis of packaging materials. Mr. Lanza is providing engineering support to GreenBlue's efforts to obtain industry-specific lifecycle data on 17 material types including seven plastics, various paper types, glass, aluminum, and steel in order to update and expand the MERGE tool (Managing Environmental Resources, Guidance and Evaluation) for analysis of the greenhouse gas, energy, and resource intensity impacts of various types of packaging materials, and is also providing similar support to the U.S. EPA Climate and Waste Program in developing in developing Greenhouse Gas emission factors for packaging materials. Mr. Lanza recently conducted site visits to solvent recovery and appliance recycling facilities in England and Germany as part of a study of the collection and destruction of unwanted ODS in appliances and bulk ODS being conducted by ICF for the Multilateral Fund Secretariat and United Nations Environment Program (UNEP).

Robert Russell is ICF's foam sector expert and will provide input for the development of methodologies and the analysis of this sector. He has over 20 years of technical and regulatory experience in insulation foams and serves as a member of UNEP's Foams Technical Options Committee. Previously, Mr. Russell was a Technical Director for Dow Chemical in the insulations foams business. His knowledge transcends across several insulation foam categories such as XPS (Extruded Polystyrene), PUR (Polyurethane) and PIR (Polyisocyanuarate) foam products. In addition, he has worked in the area of ozone-depleting substances and GWP-reducing substitutes across many product sectors, including foams. Mr. Russell has conducted past LCCP studies on foams used in residential and commercial building construction applications across blowing agents similar to those being analyzed in this study. He is also knowledgeable of the value of LCCP analysis results in highlighting the benefits of foam insulation products and their corresponding blowing agents to regulators and the International Community. Mr.Russell has worked on several projects supporting the U.S. EPA's Global Programs division on projects involving ODS and GHG analyses.

Philip Groth will serve as ICF's programming expert. Mr. Groth serves as the lead programmer of EPA's Vintaging Model, a model that characterizes emissions of ozone-depleting substances and their substitutes. Mr. Groth assists with the technical development of multiple applications and models using Visual Basic for Applications (VBA) and Microsoft Excel. He has extensive experience developing and maintaining spreadsheets and databases, performing literature- and Internet-based research, and writing and editing technical and outreach-oriented documents. Mr. Groth also has experience with mitigation analyses of a wide array of high-GWP sources.

Katrin Moffroid is a Senior Associate at ICF International with over 8 years of consulting experience providing climate change and stratospheric ozone related technical and policy support to the U.S. Environmental Protection Agency (EPA), state governments, the Australian Greenhouse Office, the New Zealand Ministry for the Environment, European Commission, and other organizations. She has provided assistance in preparing national and state-level inventories and modeling both emission and reduction opportunities for greenhouse gases. Ms. Moffroid has extensive modeling expertise for both emission inventories and mitigation options of high-GWP gases within the ODS substitute sectors, including for publications such as the *U.S. Inventory of US Greenhouse Gas Emissions and Sinks* and *Global Mitigation of Non-CO_2 Greenhouse Gases.* In addition, Ms. Moffroid was the lead model developer for a tool to estimate GHG abatement options for the government of New Zealand.

Jessica Kyle will oversee the literature review and provide sector expertise. Ms. Kyle is experienced at conducting analyses on production, consumption, and emissions of ODS substances and their High-GWP substitutes. She has over four years experience conducting analyses in the production sector for HCFCs and HFC alternatives, focused primarily on the refrigeration and AC sectors. Ms. Kyle has developed estimates of ODS stockpiles and banks by sector in the United States and worldwide, as well as estimated emission reductions resulting from destruction of those inventories and has also estimated ODS inventories by end use for the European Commission DG Environment. For these projects, Ms. Kyle analyzed accessible ODS banks contained in equipment in the fire protection (including halon 1211 in portables) and refrigeration/air-conditioning sectors.

Pankaj Kumar is an associate with ICF International in the company's Energy and Resources Practice. Mr. Kumar is an experienced researcher, data analyst, and writer on economic, scientific, and policy issues related to ODS destruction. He supported the preparation of several

reports for the U.S. EPA's significant new alternatives policy program for ODS alternatives. Recently, Mr. Kumar has worked on designing an offset project protocol for the U.S. EPA to determine GHG emissions saved by the destruction of ODS at end-of-life; the protocol was adopted by the CCX as the world's first and only non-Kyoto GHG offset project type.

Sarah Menassian will provide support for all tasks on this project. Ms. Menassian has experience conducting analyses on recovery, reuse and destruction practices for high-GWP ozone depleting substances in the EU-27 for the European Commission. She also works with the U.S. EPA to track the production, import, export, destruction and transformation of ODS for domestic regulatory purposes.

Tristan Kessler will provide support for the literature review, data analysis and report writing of this project. Mr. Kessler has experience modeling the production, consumption, and emissions of ODS substances and their high-GWP substitutes through ICF's Vintaging Model. He participated in an analysis on the imports, exports, and domestic production of HFCs, PFCs, SF_6, and NF_3 for U.S. EPA, specifically researching the imports of HFCs into the U.S. He is familiar with high-GWP emissions from industry, having worked on the Industrial Processes chapter of the U.S. Inventory, as well as a Sector Strategies report for U.S. EPA that included an estimation and discussion of emissions from the aluminum and semiconductor industries. Mr. Kessler is also an experienced researcher, having performed research tasks and literature reviews for a variety of projects, including a literature review of recent lifecycle analyses on waste management strategies.

Subcontractors and Consultants

Stefan Unnasch is a Senior Partner at Life Cycle Associates who will be serving as a technical expert for the lifecycle analyses. Mr. Unnasch has performed fuel cycle analysis studies since 1987 were he developed analytical approaches that take into account the environmental constraints that apply to California. He develops models of well-to-wheel energy impacts and emissions including criteria pollutants, toxics, greenhouse gases, and global energy inputs. These analyses have included assessing the resource mix and transportation modes for fuel production, process modeling of fuel production plants, and vehicle drive cycle analysis. He has developed spreadsheet and database models that enable the calculation of regional specific emissions as part of a full fuel cycle analysis. His work on California fuel cycle analysis efforts includes serving as the Co-Chairman of the Societal Benefits Topic Team for the California Hydrogen Highway Blueprint Plan, support of California AB1007, and the Low Carbon Fuel Standard. Mr. Unnasch was a participant in Annex XI, Lifecycle of Fuels, and Annex XV Fuel Cell Systems for Transportation under the International Energy Agency Operating Agreements. In this effort, he worked with a group of international experts on assessing the lifecycle emissions from conventional and alternative fuels. He also was the key U.S. contributor to Annex XV, Fuel Cell Systems for Transportation.

Richard Plevin, a Senior Partner at Life Cycle Associates will also be conducting the lifecyle analysis portion of this project. Mr. Plevin has developed energy and greenhouse gas studies of ethanol production systems for fuel producers, regulators (in the UK), and for scientific publications. His masters paper at UC Berkeley focused on the differential climate impacts of biofuel production systems, and the uncertainties therein. Mr. Plevin was a member of the UC Berkeley study team preparing a report on the state's Low Carbon Fuel Standard for the California Air Resources Board. He co-authored the sections of the report dealing with biofuels, lifecycle analysis, uncertainty, and compliance. He also served as peer reviewer for the biofuels sections of the AB 1007 Full Fuel Cycle Analysis study. Richard co-developed the ERG Biofuel Analysis Meta-Model (EBAMM) to compare six bioethanol

energy analyses to understand the divergence in published results. He lead the model design and implementation effort, and contributed significantly to the highly-cited paper published in Science, January 2006, as well as the extensive Supporting Online Materials. Mr. Plevin is a co-author of Life Cycle Associates' BEACCON (Biofuels Emissions and Cost Connection) model, which estimates lifecycle emissions, energy, and cost for corn ethanol production.

Brent Riffel is an engineer at SDV-SCC, Inc., where he conducts lifecycle emissions and energy analyses and cost estimation for conventional and alternative fuel pathways. He is experienced with developing LCA tools and providing support for public policy making. Mr. Riffel has conducted lifecycle analysis since 2003 using the GREET and LEM models. He has performed numerous scenario analyses and examined the uncertainty and sensitivity of model results. Brent has provided results to numerous organizations, including UC Davis, California Air Resources Board, CEC and Argonne National Lab. He is extremely familiar with both models and has expanded the LEM and built custom analytical tools using components from GREET. Brent is also a co-author of the BEACCON (Biofuels Emissions and Cost Connection) model, which estimates lifecycle emissions, energy and cost for corn ethanol production.

Robert Ewing is the owner and founder of ICF's subcontractor, SDV-SCC, Inc., a Disabled Veteran Business Enterprise (DVBE) and Small Business Enterprise (SBE), Certified by the Office of Small Business and DVBE Services, Department of General Services, State of California, Mr. Ewing has experience in complex startup and turnaround situations, financial management, organizational development, and systems planning and implementation.

6 References

Section 6 is organized into two sections: Section 6.1 provides a brief overview of ICF International, and Section 6.2 presents selected project descriptions with references of work similar to the nature of the work for this project.

6.1 ICF International Overview

ICF International is a leading management, technology, and policy consulting firm with more than 3,000 professionals worldwide. Drawing upon its extensive industry knowledge, highly credentialed professionals, and innovative analytics, ICF professionals develop solutions to complex energy, environment, emergency management, community development, and transportation issues. For more than 20 years, ICF has earned a reputation in the field of climate change consulting for its analytical rigor, in-depth expertise, and technical integrity through scores of greenhouse gas (GHG) emissions related assignments. ICF's approach to these issues is strengthened by its expertise in information technology, organizational improvement, and communications. Since 1969, ICF has been serving major corporations, government at all levels and multinational institutions from key business centers in Europe, North America, and the Pacific Rim. ICF has more than 20 offices around the world, including London, Washington, DC, Moscow, Toronto, Rio de Janeiro, New Delhi, and Beijing.

ICF offers more than 20 years of experience in the analysis of technical, public policy, and economic considerations that are relevant for climate change and almost 15 years of experience in the development of material lifecycle emission factors related to packaging, waste materials, and climate change.

The ICF Team has an outstanding group of professionals with expertise in both programs to reduce emissions of ozone depleting substances and lifecycle assessment. The ICF Team runs a mission support contract on Implementation of Programs for Stratospheric Ozone Protection for US EPA's Stratospheric Protection Division with a broad scope of work to support the phaseout of ozone-depleting substances (ODS) under the Clean Air Act and its Amendments. Our team has also conducted ODS phaseout projects for the European Commission, the World Bank, the United Nations Environment Programme, and the Australian Greenhouse Office. Our team includes staff with extensive ODS stockpile management, ODS destruction, and lifecycle inventory experience, particularly as these topics relate to GHG emissions, energy use, and the impact of waste disposal decisions on emission levels and energy consumption. We have conducted analyses and supported multiple programs related to ODS stockpiles for U.S. EPA. The ICF Team has carried out ODS destruction projects for a variety of clients at the sector, national, and international level. Through our longstanding support of the Climate Change and Waste program of the U.S. Environmental Protection Agency, the ICF team members have developed lifecycle GHG and energy emission factors for more than 25 materials types and categories. This ICF team has also been instrumental in the development of such landmarks as the report *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*. Through our work with EPA, we also supply stakeholder support to numerous government, non-profit, and private organizations, including Wal-Mart, Toyota, and the Oregon Department of Environmental Quality.

Specifically, ICF has consulted on ODS and GHG issues relating to:

- Management of ODS Stockpiles, including most recently the management of two U.S. EPA voluntary programs and one private sector analysis in the refrigeration sector. ICF supports EPA's Responsible Appliance Disposal (RAD) Program, a new voluntary program for municipalities, retailers, manufacturers and utilities, to promote the responsible disposal of refrigerated appliances, including refrigerators/freezers, window air-conditioning units, and dehumidifiers. The program seeks to ensure the proper disposal/recycling of ozone-depleting refrigerant and foam, greenhouse gas refrigerant, and hazardous materials, including PCBs, mercury, and used oil. ICF also supports EPA's GreenChill Program, an EPA cooperative alliance with the supermarket industry and other stakeholders to promite the adoption of technologies, strategies, and practices that reduce emissions of ODS and GHGs and increase refrigeration system energy efficiency. For the Appliance Recycling Centers of America (ARCA), ICF assessed the ODS contained in appliance polyurethane foam in California.

- ODS Destruction for the UN Multilateral Fund (MLF), ARCA, U.S. EPA, and European Commission (EC). ICF prepared a report for the U.S. EPA Significant New Alternatives Policy (SNAP) Program on substitutes for ODS and on available destruction technologies for ODS, including rotary kiln incineration, thermal destruction in cement kilns and lime kilns, and non-thermal chemical treatment technologies. ICF researched the current techniques being used for ODS disposal, identified and prepared process descriptions for available thermal and non-thermal ODS destruction technologies. Additionally, ICF developed a project for the Chicago Climate Exchange to provide carbon credits to industries for the destruction of ODS. The project was accepted for trading in the carbon markets as the world's first ODS project offset type in 2007. For California's Appliance Early Retirement and Recycling Program and ARCA, ICF assessed the most economically and environmentally efficient technology for destroying ODS in appliance polyurethane foam in California. Based on technical (environmental) and economic feasibility, the report assessed the most appropriate technology for the destruction of polyurethane foams in California, and estimated the total cost of destruction on two bases: cost per refrigerator destroyed and cost per pound of ODS destroyed. For the MLF, ICF is currently reviewing the systems and procedures in place to collect and destroy unwanted ODS contained in household appliances and in bulk in order to provide guidance on how best to establish appropriate management systems for the treatment of unwanted ODS in developing countries. Finally, for the EC Directorate-General (DG) Environment in Brussels, ICF conducted a study to identify the best available technologies and environmental practices concerning the prevention and minimization of leakages and emissions of ODS in connection with recovery, recycling, reclamation and destruction activities.

- Lifecycle Assessments. Over the last year, ICF has begun applying its lifecycle expertise to the assessment of the GHG and energy impacts of packaging design decisions. We are in the process of updating our material emission factors with current data from numerous industry trade associations. Through this work, we will assess the lifecycle GHG emissions, energy intensity, resource intensity, and toxicity for 17 materials. These findings will then inform supply chain decision-making by the Sustainable Packaging Coalition. The updated emission factors will also populate Wal-Mart's highly-

anticipated Sustainable Packaging Scorecard. ICF has also developed three widely used energy and GHG online calculation tools the Waste Reduction Model (WARM), the Recycled Content Tool (ReCon), and the Durable Goods Calculator (DGC).

6.2 ICF Project Descriptions and Client References

In this section, we provide three project descriptions with references of work similar to the nature of work required for this project. Following the three project descriptions that include contacts and service values as requested by the ARB, we include a set of other past project descriptions that further describe our experience in the areas of ODS stockpiles and emissions management, ODS destruction and reclamation, lifecycle analysis, High-GWP end-of life options, GHG emission reduction analyses, and general high-GWP gases and ozone depleting substances (ODS).

Project Description #1
Project Title: Study on the Collection and Destruction of Unwanted ODS in Appliances and Bulk ODS
Name of Client: UN Multilateral Fund Secretariat (UNEP)
Dates of Service: 2007-Present
Description: ICF is reviewing the systems and procedures in place to collect and destroy unwanted ODS contained in household appliances and in bulk in order to provide guidance on how best to establish appropriate management systems for the treatment of unwanted ODS in developing countries. Specifically, ICF is reviewing the systems and procedures in place in nine countries: Australia, Colombia, Canada, the Czech Republic, Germany, India, Japan, the United Kingdom, and the United States. ICF developed surveys to collect information from each of these countries and conducted country visits to each one. Based on the successes achieved and challenges faced in these countries, the report will provide recommendations as to how Article 5 countries could best handle their stocks of unwanted ODS. Contact: Stephen Sicars, United Nations Multilateral Fund Secretariat, 1800 McGill College Avenue, 27th Floor, Montreal, Québec, Canada H3A 3J6, +1 (514) 282-7867, stephan.sicars@unmfs.org Service Value: $360K

Project Description #2
Project Title: Technical and Economic Analyses of Recovery, Treatment, and Disposal of Ozone-Depleting Substances (ODS)
Name of Client: U.S. EPA
Dates of Service: 2002
Description: ICF prepared a report for the U.S. EPA Significant New Alternatives Policy (SNAP) Program on substitutes for ODS and on available destruction technologies for ODS, including rotary kiln incineration, thermal destruction in cement kilns and lime kilns, and non-thermal chemical treatment technologies. ICF researched the current techniques being used for ODS disposal, identified and prepared process descriptions for available thermal and non-thermal ODS destruction technologies. ICF also prepared a cost and technical assessment for the California Appliance Early Retirement and Recycling Program of technologies for treatment and disposal of ODS-containing polyurethane foam recovered from recycling used household refrigerators. ICF assessed the cost, regulatory, and performance aspects of recovering foam from the used refrigerators, transporting the recovered foam to disposal facilities, and disposing of the foam in municipal solid waste incinerators and municipal solid waste landfills. Contact: Julius Banks, U.S. Environmental Protection Agency, Ariel Rios Building,1200 Pennsylvania Avenue, N.W., Washington, DC 20460, (202) 343-9870, banks.julius@epa.gov Service Value: $22K

Project Description #3
Project Title: Voluntary Responsible Appliance Disposal (RAD) Program
Name of Client: U.S. EPA
Dates of Service: 2006 – Present
Description: ICF has assisted EPA with the launch and implementation of the Responsible Appliance Disposal (RAD) Program, a new voluntary program for municipalities, retailers, manufacturers, and utilities to promote the responsible disposal of refrigerated appliances, including refrigerators/freezers, window air-conditioning units, and dehumidifiers. The program seeks to ensure the proper disposal/recycling of ozone-depleting refrigerant and foam, greenhouse gas refrigerant, and hazardous materials, including PCBs, mercury, and used oil. ICF supported the development/design of the program by conducting research on the current state of appliance disposal/recycling in the U.S., as well as the costs to implement responsible programs that not only comply with federal laws, but go beyond. ICF provides ongoing program implementation, including technical and outreach/communications support. Contact: Evelyn Swain, U.S. Environmental Protection Agency, Ariel Rios Building, 1200 Pennsylvania Avenue, N.W., Washington, DC 20460, (202) 343-9956, swain.evelyn @epa.gov. Service Value: $100K

The remainder of Section 6.2 provides lists of other selected ICF past project descriptions that further describe our experience. Specific projects are presented in the following categories: (a) ODS Destruction and Reclamation, (b) Management of ODS Stockpiles and Emissions, (c) Lifecycle Analyses, (d) GHG Emissions Management, and (e) Other ODS Experience.

ODS Destruction and Reclamation

- **EC Best Available Technologies and Practices for Minimizing Emissions of ODS, European Commission (2005).** For the European Commission Directorate-General (DG) Environment in Brussels, ICF conducted a study to identify the best available technologies and environmental practices concerning the prevention and minimization of leakages and emissions of ODS in connection with recovery, recycling, reclamation and destruction activities. Information was collected from Member State representatives and companies involved in the recovery, recycling, reclamation and destruction of ODS—namely those involved in halon recovery, halon system decommissioning, the servicing, maintenance, and demanufacturing/decommissioning of refrigeration/air conditioning equipment, and the destruction of ODS fluids and foams. Based on collected survey data, in addition to existing technical or other information, ICF prepared an assessment of best available technologies and best environmental practices, to help foster an improved understanding of available and superior options for handling ODS among industry and decision makers throughout the EU-25.
- **Analysis of ODS Destruction in the U.S. and Abroad, U.S. EPA (2006-2007).** ICF prepared a report on the state of ODS destruction in the U.S., which will be released for public comment in the near future. This report contains (1) an extensive discussion of the relevant U.S. regulations affecting ODS, and more generally, hazardous waste destruction, including requirements under the Resource Conservation and Recovery Act (RCRA) and the Maximum Achievable Control Technology (MACT) standard for hazardous waste combustors; (2) a discussion of the emissions associated with the destruction of ODS and how these emissions might affect the capacity for ODS destruction in the U.S.; (3) a list of the known destruction facilities in the U.S. and the quantities of ODS destroyed in 2003 and 2004; (4) a discussion of the Montreal Protocol recommended criteria for the destruction of ODS and whether the U.S. facilities are and/or could meet these criteria; and (5) a summary of the costs for ODS transportation and destruction. Earlier version of this report also included a discussion of ODS destruction facilities abroad and the relevant regulations in several countries.
- **Destruction of ODS for Carbon Credits, U.S. EPA (2006-present).** ICF is currently supporting work to provide carbon credits to industries for the destruction of ODS—in lieu of indefinite storage or venting. The project was accepted for trading in the carbon markets as the world's first ODS project offset type in 2007 and companies can receive carbon credits for the destruction of their ODS. To this end, ICF has helped develop a guidance document for determining and granting credits for ODS destruction. Additionally, in order to verify the destruction and removal efficiency (DRE) achieved during ODS destruction, ICF has contacted several U.S. destruction facilities about the possibility of testing the DRE achieved during the destruction of halons and/or CFCs and has researched the appropriate sampling and analytical methods to be used for this test. ICF has also supported the development of estimates of the total U.S. bank of ODS that may be

available for destruction in the future, demonstrating the strong need for a program to promote the destruction of this ODS.

- **Methodology for Baseline Development and Measurement for an Ozone Depleting Substance Offset Project: Destruction of Ozone-Depleting Substances from Stockpiles or Equipment, U.S. EPA (2006).** For the U.S. EPA, ICF prepared a methodology for determining the ODS emissions offset by the destruction of ODS from either stockpiles or equipment as opposed to maintaining this ODS in the stockpiles/equipment. ICF first prepared an analysis of the possible emissions sources associated with the various management scenarios for ODS at the end-of life and conducted research and contacted several industry experts to compile information and data on the emissions of ODS associated with each management scenario, including emissions from equipment, storage, transfer, and destruction. ICF then prepared a report presenting the methodology and several examples of the emissions of potential ODS destruction projects as compared to the emissions of the baseline cases of continued storage or use in equipment, which would result in additional emissions of ODS. ICF also prepared a Microsoft Excel based tool to be used by companies to determine the potential emissions savings associated with an ODS destruction project as compared to a baseline case.

- **Vietnam Mobile Air-Conditioner Recovery & Recycling Project, UNDP (1990).** Under contract to UNDP, ICF assisted UNDP, the U.S. EPA, and the Government of Vietnam to prepare project proposals and design a detailed implementation plan for a demonstration project to recover and recycle ODS in Vietnam's MAC sector. ICF's activities included conducting market and technical surveys in Hanoi and Ho Chi Minh City and preparing draft and final project proposals and implementation plans.

- **ODS Destruction Report, U.S. EPA (2001).** For U.S. EPA's Global Programs Division, ICF drafted a report on the destruction of ODS worldwide. ICF contacted industry experts to verify and collect data on the amounts and types of ODS destroyed, researched the various types of destruction technologies used to destroy ODS, as well as the emissions and ODS capacity of each destruction system, and the reported quantity of ODS destroyed in 2000.

- **Refrigerant Reclamation in the United States during the Calendar Year 1999, U.S. EPA (1999).** For U.S. EPA, ICF authored a report detailing the refrigerant reclamation and destruction processes and practices in the United States. The report also explained the legislation and terminology used within the reclamation industry, identified the types and amounts of refrigerants reclaimed in 1999, and served as the most current, comprehensive resource of U.S. refrigerant reclaimers and destruction companies.

Management of ODS Stockpiles and Emissions

- **U.S. Vintaging Model and Analysis of Phaseout Scenarios for ODS, U.S. EPA (Ongoing).** ICF has developed and is continually improving EPA's Vintaging Model (VM), which is designed to estimate annual ODS and ODS substitute emissions from industrial sectors that use or have historically used ODS. The VM estimates emissions from five end-use sectors: air-conditioning and refrigeration, foams, aerosols, solvents, and fire-extinguishing, including 40 independently modeled end-uses. The VM synthesizes data on market size and growth, chemical use, and transitions from ODS to alternatives from a

variety of sources, including regular input from relevant industries. ICF is responsible for the continued development of the VM and updates it regularly using published sources such as UNEP Technical Options Committees reports and personal communication with industry members. The model is used to develop HFC emission estimates for the Inventory of US Greenhouse Gas Emissions and Sinks and whenever EPA requires estimates of emissions from ODS substitutes. The model is often used to perform sensitivity analyses. ICF is responsible for the continued development and updating of the EPA's Vintaging Model through reviews of new literature and working with EPA and members of industry to ensure that model assumptions of industry growth rates, market sizes, chemical use, and other parameters coincide with industry estimates.

- **Assessing the Environmental Impacts of the California Appliance Early Retirement and Recycling Program, ARCA (2002).** For the Appliance Recycling Centers of America (ARCA), ICF assessed the most economically and environmentally efficient technology for destroying ODS in appliance polyurethane foam in California. Based on technical (environmental) and economic feasibility, the report assessed the most appropriate technology for the destruction of polyurethane foams in California, and estimated the total cost of destruction on two bases: cost per refrigerator destroyed and cost per pound of ODS destroyed.
- **Analysis of ODS Emissions due to Leaks and during Service/Disposal of Refrigeration/Air-Conditioning Equipment; U.S. EPA (2001).** In support of U.S. EPA's efforts to implement the Class I Phaseout, the Mobile Air-Conditioning (MAC) Recycling Rule, the National Refrigeration Recycling Rule, and the Safe Alternatives Program, ICF assessed CFC and HCFC emissions from equipment used in the MACs, air-conditioning, and refrigeration sectors. This required the development of estimates of the frequency and size of emissions from typical equipment in each end-use during manufacture, leakage, service, and disposal. These estimates were obtained through a series of meetings with industry experts, literature review, and an examination of industry responses to questionnaires. ICF also assessed the reduction in emissions that could be achieved by implementing recovery or recycling at service and disposal. Emission estimates with and without recycling were reported on both on a per-piece of equipment basis and in terms of total emissions for each end-use sector.

Lifecycle Analyses

- **Comparative Lifecycle Analysis of Brazilian Sugarcane Ethanol and North American Ethanol, 2007, Canadian Renewable Fuels Association (2007).** The purpose of this study was to understand the environmental characteristics and in particular, the emissions of GHGs of ethanol produced from sugarcane in Brazil on a lifecycle basis. The study also evaluated North American ethanol production and distribution from different types of feedstock including corn, cellulosic, and wheat. A lifecycle comparison between Brazilian sugarcane ethanol and North American ethanol was provided in terms of global warming potential and net energy balance, ensuring that system boundaries were comparable. Because Brazilian ethanol would need to be imported, GHG emissions and energy associated with international logistics were also taken into account.
- **Lifecycle Assessment Implementation Support, The Energy Foundation.** Under the Low-Carbon Fuel Standard (LCFS) fuel producers selling into the California transportation fuel market in the state of California will be required to compute specific global warming

intensities (GWIs) for a variety of transportation fuels based on individual production pathways. The California Air Resources Board (ARB) will need to make an assessment of the GWI and related environmental impacts for a variety of fuel options on a full fuel cycle basis. These calculations will need to be performed in a transparent, consistent, and well documented manner. ICF's subcontractor, Life Cycle Associates, is supporting ARB's development of the analysis for the LCFS. Included in this effort are analyses of system boundary requirements and co-product credits for fuel production pathways, land use change, and economics as well as exercising the GREET model for California specific inputs. Life Cycle Associates recently developed a detailed analysis of corn ethanol and soybean biodiesel pathways that allowed for an evaluation of different co-product allocation techniques. Life Cycle Associates also developed a sensitivity analysis for refinery energy inputs to determine the range in GWI for gasoline and diesel fuel.

- **Lifecycle Climate Performance (LCCP) Analysis for Foams Used in Residential and Commercial Construction Applications, Dow Chemical (1999).** ICF has completed various Lifecycle Climate Performance studies on insulation foams used in residential and commercial construction applications. These studies included calculating LCCP for various foam types such as PU, PIR and XPS, that were made with different blowing agents such as HCFCs, HFCs, hydrocarbons, CO_2 and blended blowing agents. Additionally, this work analyzed the performance of products and blowing agents over the useful life of the structures.

GHG Emissions Management

- **Marginal Abatement Cost Curves for Non-CO_2 Gases in California, California Energy Commission (2006).** ICF estimated the costs of reducing GHG emissions from non-CO_2 gases in California. ICF developed a business as usual scenario for all sources of non-CO_2 gases in California through 2020. This business as usual scenario was used to calculate potential emission reductions associated with various strategies for reducing emissions in each of 7 broad industry sectors: petroleum systems, natural gas systems, manure management, solid waste management, semiconductor manufacturing, electric power systems, and refrigeration/air conditioning. These cost analyses have focused on a wide range of sources including landfills, natural gas systems, and livestock manure management, substitutes for ozone-depleting substances, electric utility systems, and semiconductor manufacturing. ICF evaluated sector strategies and their associated project costs, project durations, reduction efficiencies and arrayed these options from least cost to highest cost to assist the state in identifying promising emission reduction measures and setting targets for state GHG emission reductions. The final report is available online at:
  http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-121.html
- **California Inventory of Greenhouse Gas Emissions and Sinks.** ICF developed California's inventory of greenhouse gas emissions and sinks under extremely stringent scheduling and budget constraints. The inventory included more than 30 emission source categories. ICF is providing follow-on assistance to the State as it considers future improvements to inventory methods. The quantification protocols written by ICF and presented in the inventory were used in the subsequent California Climate Action Registry Protocol.

- **High-GWP Gas International Marginal Abatement Cost Curves Models and Report, U.S. EPA (2003-2006).** ICF created an application to facilitate the analysis of a vast store of information on international emissions baseline projections and the costs of potential emission mitigation options within various end-use sectors emitting high-GWP gases. This application integrates discounted cash flow analysis for emission reduction options, and is used to calculate and compile marginal abatement cost curves. The tool enables users to adjust analyses by changing several key economic variables such as discount rate and tax rate scenarios, and will allow policy makers to easily analyze and compare custom-tailored scenarios, their impacts on global and regional emissions, and the financial implications of required emission reductions. ICF used the tool to generate the output for the marginal abatement cost curve analyses developed for EPA. ICF sector experts evaluated the technical feasibility of mitigation options for sectors using high-GWP gases as substitutes for ozone depleting substances including the solvents, aerosols, foams, fire-extinguishing, and refrigeration and air-conditioning industry, and industrial sources such as petroleum systems, natural gas systems, aluminum production, magnesium production and processing, and electric transmission and distribution. ICF supported the preparation of two main reports of the analysis for EPA; these reports are available at:
  http://www.epa.gov/methane/pdfs/GreenhouseGasReport.pdf and
  http://www.epa.gov/methane/pdfs/SectionIVIndustrialProcesses.pdf
- **Inventory of U.S. Greenhouse Gas Emissions and Sinks, U.S. EPA (1990-Present).** ICF has supported the development of every official U.S. emission inventory submission to the UNFCCC since its inception in the form of EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks (U.S. Inventory)—totaling 11 official reports. ICF prepares emissions estimates for the majority of sources contained in the U.S. Inventory, including all sources in the Energy Chapter with the exception of Coal Mining and Abandoned Underground Coal Mines; all sources in the Industrial Processes chapter and Solvent and Other Product Use chapter; Enteric Fermentation, Rice Cultivation, Agricultural Soil Management (in conjunction with Colorado State University (CSU)), and Field Burning of Agricultural Residues in the Agriculture chapter; and all sources in the Land Use, Land-Use Change, and Forestry (LULUCF) chapter (some in conjunction with CSU and the UDSA Forest Service). In preparing these estimates, ICF consults the latest guidance available from the IPCC. We work with EPA to choose the highest-tier methodology consistent with the available data, and are always seeking to improve the quality of existing data, to find new sources of data, and to provide more accurate and U.S.-specific emission factors. In addition to preparing most of the emission estimates for the Inventory, ICF also plays the role of Inventory coordination contractor, collecting, checking, combining, analyzing, and preparing for publication the collected data. Most importantly, ICF oversees the preparation of the official documents, spreadsheets, and Common Reporting Format (CRF) Tables, using the CRF Reporter, for submissions to the UNFCCC. We subsequently supervise and carry out the process of transforming the Microsoft Word document submitted to the UNFCCC into a beautifully laid out, 2-color bound book, an annual "Fast Facts" poster, and a standalone Executive Summary.
- **California Climate Change Action Registry's GHG Reporting and Certification Protocols.** Through our (former ADL) staff, we prepared the California Climate Change Action Registry's GHG Reporting and Certification Protocols. These guidance documents

set out the methodologies and management systems for Registry participants to follow when preparing GHG emissions reports and conducting independent certifications of their reported emissions.

- **Support to the California Climate Action Team, California EPA (2005-2006).** In support of Governor Schwarzenegger's Climate Action Team, ICF led the Market-Based Options Subgroup to develop a report on options for designing a cap and trade program to limit greenhouse gas (GHG) emissions in the State of California. ICF developed the concept for the paper, and led an inter-agency team to collect data, analyze program options, and draft the report. The Subgroup included participation of representatives from multiple departments, including the California Energy Commission, the California Public Utilities Commission, the Air Resources Board, Caltrans, Finance, the Resources Agency, and others. ICF examined alternative cap and trade program designs, assessing options for: program scope; emission allowance distribution; GHGs to include; emission offsets; and enforcement mechanisms. Additionally, potential environmental justice issues were considered. The subgroup report titled Cap and Trade Program Design Options was completed in December 2005. ICF reviewed and compiled stakeholder comments on the draft subgroup report and the draft Climate Action Team report, focusing on comments relating to the use of market based mechanisms to limit emissions, and the scope of the proposed state policies. ICF also contributed to the drafting of the final Climate Action Team Report, focusing on the market-based options and the industries that could potentially be included in the program. The final Climate Action Team Report was submitted to the Governor and the legislature on April 3, 2006.

- **Guide to Incorporating Energy and Greenhouse Gas Emissions in Transportation Decision-Making, California Department of Transportation (2006- Present).** ICF is providing transportation professionals at the state, metropolitan, and local level with the information they need to better incorporate energy and GHG emissions into the transportation decision-making process. The project will produce a guidebook that provides detailed guidance on methods and data to analyze energy and GHG impacts during transportation planning, project development, and operations, and describes strategies to mitigate transportation GHG impacts in each mode and at each governmental level.

- **Development of IPCC Guidelines for National GHG Inventories Workbook, U.S. EPA/OECD.** Participants in IPCC meetings on GHG inventories expressed the need for a simplified presentation of the inventory methodology. As a result of this suggestion, ICF worked with the USEPA and OECD to prepare a "cookbook" version of the methodologies presented in *Estimation of GHG Emissions and Sinks, Final Report Volume.* The result of this project is the *IPCC Guidelines for National GHG Inventories, Volume 2, GHG Inventory Workbook.*

- **Use of Alternatives to Synthetic Greenhouse Gases Used in Montreal Protocol Industries in Australia, Australia Greenhouse Office (2003).** For the Australia Greenhouse Office, ICF evaluated the opportunities to reduce emissions of high global warming potential (GWP) gases from the refrigeration and air-conditioning, fire protection, aerosols, foams, and solvents industries in Australia. To this end, ICF designed and prepared surveys to be completed by Australian industry representatives, which provided the basis for the study. The analysis reports on the most appropriate and promising

alternative technologies or gases that can be used within these five industries, their estimated market penetration and extent of future adoption, and their associated market barriers, including technical, safety, cost, and other reported impediments.

- **Analysis of Abatement Options for High-GWP Gases in Montreal Protocol Industries, International Energy Agency (2002-2003).** For the International Energy Agency (IEA), ICF supported an international project involving high-GWP gas emissions projections worldwide and cost assessments of mitigation options at various discount and tax rates. Specifically, marginal abatement cost estimates were developed by technology option for sources of HFCs, PFCs, and SF_6, including: HFCs and PFCs as substitutes for ozone-depleting substances in the refrigeration/air-conditioning, foams, solvents, fire protection, and aerosols sectors, SF_6 from magnesium metal casting, PFCs from aluminum metal smelting, SF_6 from electric utility transmission and distribution equipment, PFCs from semiconductor manufacturing, and HFC-23 from HCFC-22 production.
- **Support for U.S. EPA's Climate Change and Waste Program, U.S. EPA (Ongoing).** Since 1993, ICF has provided analytic and programmatic support for the U.S. EPA's Climate Change and Waste Program, one of the elements of the U.S. Climate Change Action Plan. This program seeks to reduce greenhouse gas (GHG) emissions via waste management by stimulating source reduction, recycling, composting, and energy recovery. Fundamental to nearly every aspect of the program has been developing and applying lifecycle emission factors to quantify the GHG impacts of alternative waste management practices. ICF developed an integrated methodology that employs a streamlined lifecycle analysis of GHG emissions and sinks associated with raw material acquisition, manufacturing, fabrication, transportation, and disposal of specific materials in the MSW-stream. ICF has analyzed the GHG mitigation opportunities associated with source reduction, recycling, landfilling (with or without CH_4 recovery), municipal waste combustion, and composting. ICF developed emission factors for a broad range of material types, including all of the major waste stream components (e.g., plastics, steel, aluminum, and various paper types). These emission factors have been widely recognized as the leading analytical tool for assessing GHG impacts of solid waste management practices and have been applied in both the private and public sectors, in the United States and abroad. They have helped decision makers accurately evaluate the results of their waste management strategies in a field where activity data and analyses are often lacking or unreliable.
- **PEW Center on Global Climate Change Industry GHG Protocol Development and Verification, PEW Center.** ICF staff, formerly of ADL, assisted the PEW Center to hold an industry dialogue on GHG emissions protocol preparation and reporting to review the existing state of art and best practices for entity-level reporting. ICF prepared the consensus GHG protocol report, based on the overview of GHG protocol issues and options. Separately, our (former ADL) staff also published a PEW Center GHG verification issues report from the stakeholder working group.
- **Fluorinated GHG (F-Gas) Reporting Forms and Summary Template, European Commission (2006-2007).** ICF has developed a set of Excel-based reporting forms to be used by producers, importers, and exporters of Fluorinated greenhouse gases (e.g., HFCs, PFCs, and SF_6) regulated under Regulation (EC) 842/2006 in the European Community. The forms capture comprehensive data on the production, import, and export

of f-gases as well as quantities placed on the EC market in various sectors and quantities destroyed and reclaimed annually. To effectively communicate data to the public, ICF developed a template for a statistical summary, which graphically displays trends and, in table format, elucidates aggregated quantities.

- **Determination of HFC Emission Reduction Potential from Recovery/Recycling, U.S. EPA (2002-2005).** For the U.S. EPA, ICF developed estimates of the emissions reductions attributable to the proposed regulations governing recovery and recycling practices in the refrigeration and air-conditioning sector. Using U.S. EPA's Vintaging Model, ICF developed baseline emissions projections, and using modeled compliance and efficiency variables, determined projected emissions under the regulation. Using a model of vehicle fleet and repair scenarios, ICF also assessed emissions reductions that may be associated with a proposed sales restriction on substitute refrigerants.

Other ODS Experience

- **Assessment of the Export of Halons for Critical Uses in the European Union, European Commission (2004-2005).** Through contact with Member State representatives and halon export companies, ICF researched historical and projected future quantities of exports of recovered, recycled and reclaimed halon for critical uses. The study aimed to determine whether a prohibition on halon exports earlier than 2010 was appropriate and found that a prohibition before 2010 is not appropriate. To conduct this research, ICF developed and disseminated Excel-based surveys to Member State representatives and halon export companies.

- **Review and Evaluation of Minimum Qualification Requirements and Programmes for Leak Reduction, Recycling, Recovery, Reclamation, and Destruction of F-Gases and ODS in the past three years, European Commission (2005-2006).** For the European Commission DG Environment, ICF reviewed and evaluated the measures taken by Member States and their associations regarding the minimum qualifications requirements and programmes (e.g., training or courses) for personnel involved in reducing leaks, recycling, recovering, reclaiming, and destroying controlled f-gases and ODS. As part of the evaluation process, questionnaires were developed for data collection from associations and organizations within the Member States pertaining to minimum qualification requirements and programmes offered. The sectors included in this analysis are stationary refrigeration/AC, solvents, fire protection, motor vehicle air conditioning, and high and medium voltage equipment containing SF_6.

- **Continuing Uses of ODS, U.S. EPA (2006).** For the U.S. EPA, ICF prepared an analysis characterizing actual and potential continuing uses of ODS in the United States. The analysis focused on continuing ODS use in the military, as well as the aerospace, civil aviation, and commercial shipping industries. The report estimated amounts of ODS (by type) installed in equipment, annual quantities required, stockpiles available, new chemical required, likely phaseout dates, potential alternatives, and barriers to the transition away from ODS.

- **Global Mobile Air-conditioning (MAC) Program, U.S. EPA (1994-1999).** ICF designed, implemented and evaluated the Global Mobile Air-conditioning (MAC) Programme for the U.S. Environmental Protection Agency. From 1994-1999, ICF staff worked in 20 countries and nearly 1,000 MAC servicing business to recover, recycle, and reclaim CFC-based

refrigerant. As part of this program, ICF was responsible for identifying and researching appropriate recycling and reclamation technology, and building ground-up programmes in each country to support a network of refrigerant recycling. Assistance included organizing local networks with local government counterparts, identifying and recruiting local technical partners, designing and delivering technical training to MAC service technicians and government personnel on CFC recycling and environmental issues, designing a bidding process for the procurement of CFC recycling technology, and evaluating the results of each project. During work on the project, ICF staff coordinated closely with major mobile air-conditioning industry associations and technology manufacturers in the U.S. and abroad. ICF staff are thoroughly familiar with the key technical issues associated with the recovery and reclaim of refrigerant in MAC systems, including issues surrounding the volume of refrigerant charge, system leakage, and refrigerant quality.

- **China Commercial Refrigeration Management Project, U.S. EPA (1995).** ICF supported the design and implementation of a bilateral U.S. EPA project in China to transfer recovery/recycling and other refrigerant management technology to enterprises in Beijing, China. ICF worked with U.S. EPA and Chinese counterparts to conduct a market study of the commercial refrigeration sector in China, specify and procure appropriate technology, coordinate with U.S. equipment suppliers, design and implement technical training, and conduct follow-up evaluations for assessing project effectiveness.

- **Assessment of the Implementation of Ozone Depleting Alternative Technologies in Developing Countries, U.S. EPA (2005).** ICF has assisted EPA in preparing an assessment of materials and technologies currently used in the building and construction sectors in China, which focused on those applications where the use of ozone depleting substances (ODS) are likely, including foam insulation, refrigeration/air conditioning, fire suppression, solvents/cleaners, and potentially others. Through this analysis, ICF has identified trends in the transition to ODS alternatives in China, and assessed the composition of ODS alternatives in the Chinese market as a result of ongoing and expected ODS phaseout activities. As part of this study, ICF has also conducted a parallel assessment of China's technical and institutional capacities to manage the transition to ODS alternatives, and to identify potential unmet capacity needs in China.

- **Development and Maintenance of Ozone-Depleting Substances (ODS) Tracking System, U.S. Environmental Protection Agency (1989, 1996-Present).** In 1989, ICF worked with EPA to develop the ODS Tracking System to enable EPA to monitor CFC, HCFC and other ODS consumption by US companies and the United States' compliance with the Montreal Protocol. Since this time, ICF has provided ongoing support including its upgrade in 1996 to a Microsoft Access-based system. The tracking system performs three fundamental activities; i) it stores information submitted by U.S. companies who are required to report ODS transactions including the production, import, export, transformation and destruction of ODS; ii) it track ODS allowances on a company by company basis; and iii) creates required statistical reports to the United Nations Environment Programme (UNEP) Ozone Secretariat that help measure the success of ozone protection efforts domestically and globally. Recently, ICF has begun assisting EPA in implementing a web-based capability for reporting companies to securely submit data supported within the EPA Information Technology Architecture (ITA). As such, EPA is able to operate a more modernized tracking system that can accept electronically submitted data in an automated manner, greatly eliminating the need of manual data

entry, a process that is time consuming and prone to error. The electronic data file transfer process designed and implemented by the ICF Team includes multiple layers of security to ensure confidentiality of online company data.

7 Project, Cost, and QA/QC Management Plans

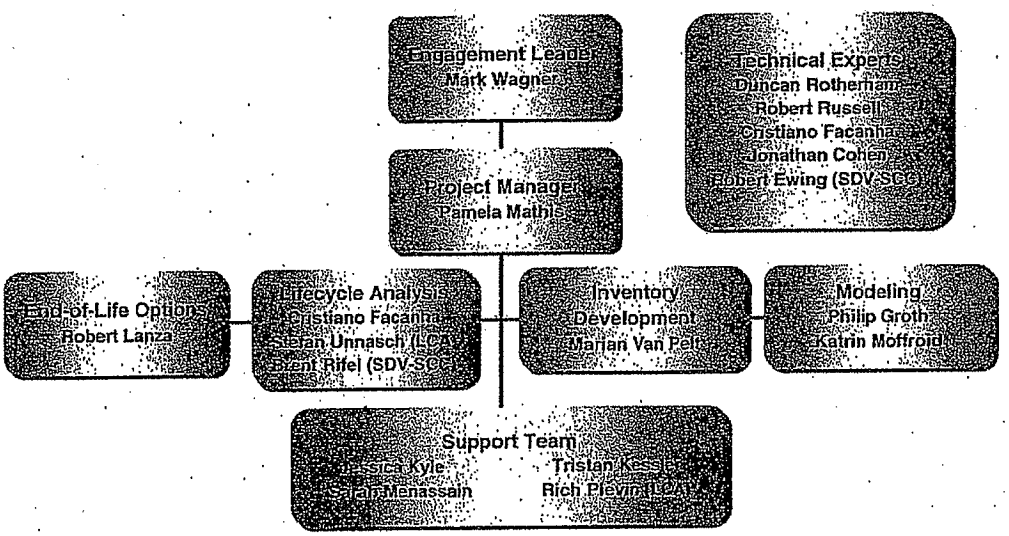
ICF has a long history of completing complex analyses in support of energy and environmental policy development. We supported the U.S. Environmental Protection Agency (EPA) through the Clean Air Act Amendments of 1990, the SIP Call rulemaking, the Clean Air Policy Initiative (CAPI), and through the multi-pollutant analysis process. We understand the need for timely, high quality analytic work that can withstand the test of stakeholder and judicial review.

Through more than three decades of experience in managing large contracts for the Federal Government, State Governments, and the private sector, we have developed managerial and administrative structures to ensure that effective project management, cost, and quality assurance controls are in place for the duration of any given project. ICF understands that implementing effective management procedures to perform and monitor the all project activities is critical to delivering an exceptional product to ARB. This section describes ICF's management plan for executing the project and focuses on the controls necessary to complete the work and provide flexibility to address project demands that are not currently anticipated.

7.1 Project Management

The ICF management approach encourages effective internal and external communication and coordination. Exhibit 7-1 presents the ICF Project Team.

Exhibit 7-1: The ICF Project Team



The management team will be comprised of an Engagement Leader and a Project Manager. The Engagement Leader, Mark Wagner, will coordinate with ICF's designated Project Manager, Pamela Mathis and, as appropriate, will serve as a point of contact for communication with ARB. Our Project Manager, Pamela Mathis, will maintain a close working relationship with her counterpart at ARB. Ms. Mathis will lead regular process meetings with ARB and undertake additional communication as needed to facilitate the performance of the work.

We will encourage communications between the ICF Team and ARB staff at all levels to ensure that information is shared effectively. As discussed in our work plan, we propose to provide ARB with modeling capability that ARB can use effectively with its staff resources.

Keys to the ICF Team Approach to Performing Work

- Assign experienced managers and technical staff
- Make quality the primary objective
- Facilitate communications between the ARB and the ICF Team
- Foster an atmosphere of information sharing within a flexible, "learning" organizational structure
- Employ state-of-the-art administrative systems to track financial and technical performance

ICF has well-defined processes to ensure proper project management throughout each project's lifecycle, including: planning and scheduling the work; performing the work; monitoring the work, and reporting on the work. Each is described in turn.

7.1.1 Planning and Scheduling the Work

Successful project oversight begins with detailed analysis of the specifications of the individual work products and/or activities.

- To initiate this project, the lead project staff will hold a kickoff meeting with ARB. This meeting will include the principal investigator, key personnel, the ARB Contract Manager, and other key ARB staff, and will occur in ARB's Sacramento offices.

- Based on the results of the kickoff meeting we will adjust our plans for performing the project as needed. Adjustments will be discussed with ARB to ensure mutual agreement to any revisions to the project plan.

As part of preparing this proposal, we placed particular emphasis on selecting the right personnel from across our Team's labor pools to ensure that we assign the most appropriate people to the project. Any adjustments to the staffing plan will be driven by changing needs of the project, as defined by ARB. Our goals are to ensure that: (1) this project is staffed to meet ARB's needs; (2) individual staff members are not over-committed; and (3) projects have continuity in staffing. Our approach to staffing is flexible and can accommodate sudden swings in project and contract intensity caused by shifting Directorate needs and priorities.

7.1.2 Performing the Work

During execution of the project, the management team will track and report progress against the project schedule, labor plan, and cost plan, reviewing technical performance and ensuring that the schedule and budget are maintained. Our managers will be in daily contact with their staff to provide technical expertise, guidance, and direction, and to resolve problems as they arise. Regular meetings and conference calls among the management team, in addition to quarterly progress reports and invoices will ensure that tasks remain targeted to ARB's needs and that the ARB Contract Manager is apprised of progress on meeting task deadlines.

The ICF Project Manager will maintain close contact with the ARB Contract Manager to update ARB on project status. In addition, as part of our monthly meetings with ARB we will provide a quarterly progress report (QPR) that will describe: (1) progress/activities during the period; (2) project developments that could result in changes to schedules, labor, or costs; (3) problems and their resolution; and (4) updated milestone/schedule status, labor management, and invoices.

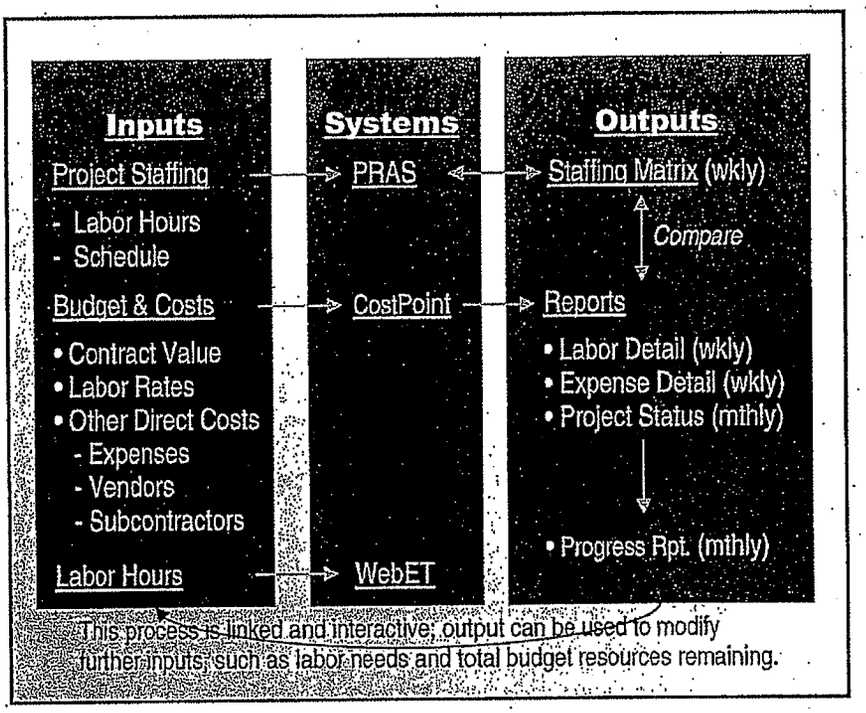
7.1.3 Monitoring the Work

It will be the primary responsibility of the ICF Project Manager to monitor the project to ensure that objectives are being met. ICF has well-developed project tracking capabilities, using Web-based electronic timekeeping and CostPoint, that enables us to generate detailed weekly project cost reports. The project management information system is depicted in Exhibit 7-2. These reports allow expenditure tracking to be synchronized with technical progress. Using these electronic tools and assigning experienced managers and key personnel will ensure that concurrent, complex tasks are managed on schedule and within budget.

7.2 Cost Management

Cost management is critical to successful project execution. This section describes our project management information system for tracking labor hours and costs, generating tracking reports, and preparing detailed financial status reports that allow the ARB Contract Manager to evaluate our contract performance.

Exhibit 7-2: ICF's Project Management Information System



ICF's state-of-the-art cost tracking capabilities are facilitated by Web-based electronic timekeeping (WebET) and the Deltek CostPoint system (see Exhibit 7-2). These tools allow project managers to generate weekly project cost reports at the task level. These reports enable expenditure tracking to be linked closely with progress made on the work plan. Using these tools, ICF's management team will ensure that ARB project is managed within budget and on schedule.

7.2.1 Monitoring Costs by Tracking Labor Hours: WebET

ICF uses an Internet-accessible electronic timekeeping system, WebET, to track labor hours on a daily basis. This system allows managers to track labor hours on the contract by category and task levels. All ICF employees enter time daily into WebET and sign their timesheet for the week by close of business on Sunday. Reports from the system are available by the Tuesday afternoon following the close of the week the previous Sunday.

On a weekly basis, the management team will receive reports that show the labor hours spent on their tasks and subtasks from the beginning of the project to the previous week. These reports will allow our managers to keep a careful watch over the rate at which labor is being used. They also facilitate the comparison of hours expended and the progress on the project in terms of deliverables and budget.

7.2.2 Monitoring Costs by Tracking Labor and Other Costs: CostPoint

ICF utilizes the Deltek CostPoint integrated financial and accounting system. CostPoint is a flexible and scalable Windows-based enterprise resource management system centered on a

project accounting system. The CostPoint system was developed specifically for, and approved by, government agencies to support their cost accounting and reporting requirements. This robust system handles an unlimited number of contracts and task orders, incorporates subcontractor cost data, and generates numerous tracking reports that project managers can access online.

The information in ICF's CostPoint tracking system is typically assembled from the following categories of basic inputs and sources:

- **Project data** comes directly from client source documents (e.g., the contract, task orders) and includes information such as the contract number, task order number, anticipated labor hours, period of performance, and amount and source of funding.
- **Personnel information** includes the name, employee number, labor category, and hourly labor rate.
- **Labor hours** by person are entered into WebET (discussed above), which is a linked part of CostPoint. The information needed to track and report labor hours and the associated costs are incorporated in the project accounting system and reports.
- **Travel and other direct costs** (ODCs) are recorded in CostPoint on a daily basis as internal and vendor costs are received. Each cost is also entered into CostPoint with a general ledger code that identifies the cost category (e.g., subcontractor, travel, reproduction, delivery, long distance telephone) and with a vendor name, vendor number, and invoice number that facilitates retrieval of more detailed invoice information, if required. In addition, the vendor number and the project code can be used in combination to aggregate and report costs by vendor, region, site, etc. to meet the Directorate's needs.
- **Subcontractor costs** are recorded as they are received from our Team members. The same project accounting codes are used to collect the information with the required attributes. Subcontractor labor hours are thus tracked and incorporated into the overall project labor and cost plans and reports.

7.3 Approach to Quality Assurance and Quality Control

The ICF Team is thoroughly committed to providing exceptional quality in every aspect of our support to ARB. The ICF Team recognizes that robust and accurate products and services are crucial to this project. ICF has an exemplary history of delivering highly technical products with exceptional quality, on time and within budget. ICF's quality management approach includes:

- Use of our quality assurance system to foster communication, customer service, and innovative applications of science and technology for problem-solving;
- Integration of the quality assurance system into management policies and systems using a systematic planning process that results in the collection, generation and use of data of the type, quantity, and quality needed for decision making; and

- Striving for continuous quality improvement, using training, assessments and performance measurements to inform employees regarding progress and opportunities.

ICF fosters quality in each project from the very beginning. This "culture of quality" is maintained during the implementation of the project and all the way through final delivery of product. This is accomplished by involving the right senior staff to oversee technical review and quality control, ensuring that the most qualified staff and most effective QA procedures are employed for each specific task. ICF has developed a proven quality assurance system, based on 30 years of providing high quality service to federal, state and other clients that can easily be tailored to meet additional ARB quality needs. This quality assurance system includes:

- *Senior Personnel with Directly Relevant Experience*: We have assigned senior personnel to lead the key tasks of the assignment. This staffing ensures that a high level of expertise is reflected in the deliverables.

- *Junior Personnel with a Broad Experience Base*: Our junior staff will perform the majority of the analysis under the direction of our technical experts. This staffing ensures that ARB receives a high quality product that is cost effective.

- *Clear Direction from Kickoff Meeting*: Quality assurance efforts begin at project initiation. We will seek clear direction on expectations, including the intended audience for the deliverables, appropriate content and format, research techniques, and key contacts and information sources.

- *Data Analysis:* Input data utilized to populate the model will be evaluated for accuracy.

- *Documentation of Guidance Received from the Client:* To ensure mutual understanding and avoid misinterpretations, we will document all key directions and guidance provided by the client and submit the documentation to the client for review.

- *Project Management Systems:* We will use ICF's full suite of project management systems, including electronic timesheets and weekly project cost reports.

- *Problem Identification and Resolution:* We will proactively identify and quickly resolve problems, including implementing corrective action in a timely manner.

- *Performance Assessment:* We will ensure quality performance based on feedback from key stakeholders and most importantly, from ARB.

- *Continuous Improvement:* We will promote a culture of continuous improvement throughout the ICF Team during the span of the project.

ICF's QA/QC procedures are backed by a corporate culture that reinforces in our staff the commitment to produce high-quality work. A corporate culture for customer service and quality permeates all levels of our organization. ICF is committed to quality assurance and continuous improvement in the level of services we provide.

8 Appendix: Resumes

This section provides the qualifications for the personnel proposed for this study. Qualifications are presented for all proposed staff in the following order:

- Mark Wagner
- Pamela Mathis
- Marian Van Pelt
- Duncan Rotherham
- Christiano Facanha
- Jonathan Cohen
- Robert Lanza
- Bob Russell
- Phil Groth
- Katrin Moffroid
- Jessica Kyle
- Pankaj Kumar
- Sarah Menassian
- Tristan Kessler
- Stefan Unnasch, Life Cycle Associates
- Rich Plevin, Life Cycle Associates
- Brent Riffel, SDV-SCC
- Robert Ewing, SDV-SCC

ICF INTERNATIONAL

MARK WAGNER

EDUCATION

S.B., Chemistry, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1981
S.B., Biology, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1981

EXPERIENCE OVERVIEW

Mark Wagner is a Senior Vice President of ICF Incorporated with 25 years of experience in the fields of technical, economic, and regulatory analysis for the European Commission, the World Bank, the United Nations Environment Programme, the Australian Greenhouse Office, the Global Environment Facility, the U.S. Environmental Protection Agency, and the U.S. Food and Drug Administration. Mr. Wagner manages ICF's 5-year, $10 million mission support contract on Implementation of Programs for Stratospheric Ozone Protection for U.S. EPA's Stratospheric Protection Division (SPD) with a broad scope of work to support the phaseout of ODS under the Clean Air Act and its Amendments. For these initiatives, he provides technical and managerial oversight in the areas of risk and toxicity screening for ODS substitutes for the solvents, refrigeration, aerosol, electronics, and metal cleaning, fire extinguishing and other end-uses; ODS and ODS substitute emission projections; health effects and atmospheric modeling; regulatory, technical, economic, and cost/benefit analyses; and ODS-replacement market characterizations to support rulemaking activities.

Mr. Wagner also provides support in international treaty negotiation sessions to clients at US EPA, the European Commission, the World Bank, and the United Nations Environment Programme regarding decisions taken under the Montreal Protocol relating to the expedited phaseout of HCFCs, destruction and reclamation of ODS, and modeling of consumption, production, and emissions of ODS. Recently he has supported initiatives in the private sector to understand opportunities to reduce emissions of high-GWP emissions through various cap and trade approaches for managing ODS and their HFC replacements.

SELECT PROJECT EXPERIENCE

Study on the Collection and Destruction of Unwanted ODS in Appliances and Bulk ODS, UN Multilateral Fund Secretariat (UNEP) (2007-Present). Mr. Wagner is providing oversight for a review of the systems and procedures in place to collect and destroy unwanted ODS contained in household appliances and in bulk in order to provide guidance on how best to establish appropriate management systems for the treatment of unwanted ODS in developing countries. Specifically, Mr. Wagner is reviewing the systems and procedures in place in nine countries: Australia, Colombia, Canada, the Czech Republic, Germany, India, Japan, the United Kingdom, and the United States. Mr. Wagner developed surveys to collect information from each of these countries and conducted country visits to each one. Based on the successes achieved and challenges faced in these countries, the report will provide recommendations as to how Article 5 countries could best handle their stocks of unwanted ODS.

EPA's Responsible Appliance Disposal (RAD) Program, U.S. EPA (2006-Present). Mr. Wagner manages ICF's support of EPA's RAD Program, including assisting EPA with the launch and implementation of this new voluntary program for municipalities, retailers, manufacturers and utilities, to promote the responsible disposal of refrigerated appliances, including refrigerators/freezers, window air-conditioning units, and dehumidifiers. The program seeks to ensure the proper disposal/recycling of ozone-depleting refrigerant and foam, greenhouse gas refrigerant, and hazardous materials, including PCBs, mercury, and used oil. To this end, Mr. Wagner oversaw research on the current state of appliance disposal/recycling in the U.S., as well as the costs to implement responsible programs that not only comply with federal laws, but go beyond. Mr. Wagner also managed the creation of partnership agreements, as well as a variety of outreach materials to educate stakeholders about the benefits of proper appliance disposal/recycling and recruit new partners—including PowerPoint presentations, fact sheets, and EPA web pages. In addition, he led the development of draft outreach strategies to engage new program partners, as

well as an Information Collection Request (ICR) for the RAD Program and an Excel-based reporting form for partners.

Destruction of Ozone Depleting Substances (ODS) for Carbon Credits, U.S. EPA (2006-Present). Mr. Wagner is managing the development of a project proposal to provide carbon credits to industries for the destruction of ozone depleting substances (ODS)—in lieu of indefinite storage or venting. The project was accepted for trading in the carbon markets as the world's first ODS project offset type in 2007 and companies can receive carbon credits for the destruction of their ODS. To this end, ICF has developed a methodology to determine the project boundary, emission baseline, and resulting emission reductions. If the project proposal is accepted for trading in the carbon markets, companies will receive carbon credits for the destruction of their ODS. As part of this work, Mr. Wagner oversaw the extensive research conducted on ODS management scenarios and associated emissions and the creation of an Excel-based tool that can be used by future program partners to determine the potential emissions savings (i.e., ozone and climate benefits) from an ODS destruction project. In addition, ICF prepared briefs on topics such as ODS destruction project concepts, benefits, and partner responsibilities.

Assessment of Cost and Environmental Impacts of the California Appliance Early Retirement and Recycling Program. For the Appliance Recycling Centers of America (ARCA), Mr. Wagner managed an analysis assessing the most economically- and environmentally-efficient technology for destroying ODS in appliance polyurethane foam in California. Based on technical and economic feasibility, the report assessed the most appropriate technology for the destruction of polyurethane foams in California, and estimated the total cost of destruction on two bases: cost per refrigerator destroyed and cost per pound of ODS destroyed.

Voluntary Program for the Reduction of ODS Emissions [Planning Stages], U.S. EPA. For the U.S. EPA, Mr. Wagner is overseeing a number of activities to help develop and, eventually, implement a voluntary program to reduce emissions of ozone depleting substances (ODS), focusing on the destruction of ODS currently contained in equipment or stored in stockpiles. The work has involved conducting preliminary research to identify the need for a program, developing a tool to help implement the program, and assisting in directing the design of the program. Mr. Wagner advised on program design, preparing briefs on program concepts; overarching issues that could affect the implementation and success of a program; potentially applicable sectors; ideas for participant achievement levels (e.g., a gold designation for companies that completely transition away from ODS use); partner benefits and responsibilities; EPA responsibilities including tools to provide; possible names; and examples of existing EPA voluntary partnerships.

Current Inventory of Ozone Depleting Substances (ODS) in the United States, U.S. EPA. Under a short lead time, Mr. Wagner managed ICF's development of a methodology and resulting estimates of the current inventory of ODS in the United States. The inventory estimates include current consumption, ODS installed in either products, (such as foams), or equipment, (such as refrigerators), and bulk ODS stored in stockpiles. ICF derived estimates from EPA's Vintaging Model and supplemented this information using data from various sources such as UNEP reports and surveys conducted by industry associations. ICF successfully delivered current inventory estimates to EPA within four days of receipt of the request.

International Workshop to Phaseout Ozone-Depleting Refrigerants in Developing Countries, European Commission. For the European Commission's Directorate-General for Research, Mr. Wagner is managing the organization of an innovative international workshop to target the reduction of HCFC consumption in developing countries between now and 2015. The workshop will provide developing country stakeholders with the technical tools needed to phaseout HCFCs (e.g., information on viable alternatives, technology transfer, and infrastructure requirements) and will target consensus-building among stakeholders on an intermediate phaseout schedule to be implemented under the Montreal Protocol prior to 2040. This work involves close collaboration with high-level stakeholders across country governments and multilateral organizations, including the World Bank, UNEP, UNDP, and UNIDO.

Energy Efficiency & Chillers, U.S. EPA. Mr. Wagner oversaw the production of a short video presentation covering several key topics to support the roll-out of a new global program to replace large commercial building chillers in developing countries with chillers that rely on non-ozone depleting refrigerants. ICF is conducting research on issues arising from the showing of the video including researching the CDM-based methodology for chiller replacement being proposed by a local commercial bank in India. This project is aimed at encouraging the installation of new chillers that are more energy efficient.

Modeling U.S. ODS and ODS Substitutes Emissions, U.S. EPA. Mr. Wagner provides management oversight for ICF's project to supply Vintaging Model support for U.S. EPA's Stratospheric Protection Division. The project involves development, maintenance, and use of the U.S. EPA's Vintaging Model for estimating use and emissions of various ozone-depleting substances (ODS) and ODS substitutes, including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Design of Reporting Format for Compilation and Analysis of Data Reported by Companies for the Import, Export, and Production of Certain Fluorinated Greenhouse Gases (F-gases), European Commission. For the European Commission, Mr. Wagner is managing the development of reporting forms and a statistical fact sheet for aggregated input of data reported by companies involved in the import, export, and/or production of regulated f-gases in the European Union. In order to ensure that all companies required to submit annual reports (beginning in 2008) are informed of their obligation to report, ICF is collecting an exhaustive list of relevant companies and contact information. To this end, ICF has obtained trade data for the regulated substances and is surveying trade associations and member state representatives to obtain a comprehensive list of companies and contact information. ICF will develop Excel-based reporting forms, a summary form, and a statistical fact sheet for the rapid compilation of reported data and display of key facts and trends.

Risk Analysis of Alternatives for Ozone-Depleting Substances (ODS), U.S. EPA. For EPA's Stratospheric Protection Division, Mr. Wagner manages the preparation of toxicity and exposure analyses and risk screens of proposed alternatives to ozone-depleting substances to support determinations made under EPA's Significant New Alternatives Policy (SNAP) program. Analyses are prepared for proposed alternatives in various end-use sectors, including fire suppression, aerosols, adhesives, coatings, and inks, integral skin, appliance and refrigeration foams, and refrigeration and air conditioning.

EC Best Available Technologies and Practices for Minimizing Emissions of ODS, European Commission. For the European Commission, Mr. Wagner is managing a study to identify the best available technologies and environmental practices concerning the prevention and minimization of leakages and emissions of ODS in connection with recovery, recycling, reclamation and destruction activities. To this end, Mr. Wagner is managing the development and dissemination of questionnaires to Member State representatives and companies involved in the recovery, recycling, reclamation and destruction of ODS—namely those involved in halon recovery, halon system decommissioning, the servicing, maintenance, and demanufacturing/decommissioning of refrigeration/air-conditioning equipment, and the destruction of ODS fluids and foams. Based on collected survey data, in addition to existing technical or other information, Mr. Wagner is overseeing the analysis and assessment of best available technologies and best environmental practices to help foster an improved understanding of available and superior options for handling ODS among industry and decision makers throughout the EU-25.

Risk Analysis of Alternatives for Ozone-Depleting Substances (ODS), U.S. EPA. For EPA's Stratospheric Protection Division, Mr. Wagner manages the preparation of toxicity analyses and risk screens of proposed alternatives to ozone-depleting substances to support determinations made under EPA's Significant New Alternatives Policy (SNAP) program. Analyses are prepared for proposed alternatives in various end-use sectors, including fire suppression, aerosols, adhesives, coatings, and inks, integral skin, appliance and refrigeration foams, and refrigeration and air conditioning.

Market Study for Strategic Phaseout of CFCs in Latin America, World Bank. Mr. Wagner managed report on the supply and demand of CFCs and CFC substitutes in Latin America. The report included

recommendations of key sectors of production and/or consumption for which the World Bank should target to expedite the CFC phaseout in Latin America.

Analysis of CFC Supply and Demand in Developing Countries, European Commission. Mr. Wagner managed preparation of report examining current and projected CFC supply and demand in Article 5(1) countries to assess the EU programme for supplying CFCs to developing countries. The analysis examines current European Community production levels for basic domestic needs (BDN) to determine whether production is contributing or will contribute to any excess in supply. The analysis also considers key variables that affect the quantity of CFCs available for BDN such as: BDN demand for CFCs in developing countries; near-term global supply of CFCs for BDN; net excess/deficit of CFCs in developing countries; and impact of recovery and recycling and illegal trade on CFC supply and demand.

Cost-Benefit Analysis of the SunWise Program, U.S. EPA. Mr. Wagner recently managed an a cost-benefit analysis of the SunWise Program based on three factors: (1) the percent of sunburns reduced by the SunWise Program; (2) the percent of Americans that are diagnosed with skin cancer in their lifetime; and (3) the percent of incidences of skin cancer that are attributed to sunburns. Based on this methodology, and using the Atmospheric Health Effects Framework, ICF calculated the avoided incidence and mortality associated with the SunWise Program under two separate scenarios: the Baseline Scenario 1999-2004 (SunWise funded at $800,000/year from 1999-2004) and for Scenario 1 (SunWise funding continues at $800,000/year for years 2005-2010). ICF then monetized these benefits and calculated the net present value of costs and benefits for both scenarios. ICF prepared a report for EPA on the methodology and results of the analysis, and participated in EPA briefings on the outcomes of the analysis.

Valuation of Human Health Effects Associated with Pesticide Use in the United States, U.S. EPA. Mr. Wagner prepared a report for EPA's Office of Pesticide Programs characterizing the human health impacts attributable to pesticide exposures. He evaluated acute and chronic exposures during manufacture and use, dietary intake, consumer exposures, and drift and migration for treated areas for all classes of pesticides. Pesticide usage by sector and the associated health impacts, including cancers, chronic and acute effects, and neurological and developmental effects were developed, as were estimates of the number of exposed individuals. Finally, the number of expected mortalities and morbidities and costs of these end points were developed to prepare a valuation of the total costs to society of conditions resulting from pesticide exposures.

Peer Review of ICF Analysis of the Acceptable Exposure Level of n-Propyl Bromide, U.S. EPA. For the EPA Significant New Alternatives Policy Program, Mr. Wagner recently managed a critical external peer review of their derivation of an industrial exposure level for nPB based on a reproductive health endpoint. As a part of the peer review process, ICF sought out the top experts in reproductive toxicology to create its external review panel. The ICF team posed numerous questions on the validity of their analysis to the peer reviewers. ICF followed up with each peer reviewer in response to their comments and questions. In the end, all reviewers concurred with ICF's rationale for selecting estrous cycle changes as the critical end point for derivation of the industrial AEL for nPB.

Review and Evaluation of Minimum Qualification Requirements and Programs for Leak Reduction, Recycling, Recovery, Reclamation, and Destruction of ODS in the European Union, European Commission. For the Directorate-General Environment in Brussels, Mr. Wagner managed a study to evaluate the measures taken by Member States and their associations regarding the minimum qualifications requirements and programs (e.g., training or courses) for personnel involved in reducing leaks, recycling, recovering, reclaiming, and destroying controlled ODS—as required by Articles 16 (5) and 17 (1) of EC Regulation No. 2037/2000. As part of the evaluation process, ICF developed and disseminated questionnaires for and collecting information from associations and organizations within the Member States pertaining to minimum qualification requirements and programs offered. Based on the feedback from these surveys, recommendations were made to the Commission on appropriate measures that should be put in place regarding the minimum qualification requirements in order to meet the

minimum qualification requirements for personnel involved in the recovery, recycling, reclamation, destruction, and/or emission reduction of ODS.

Technical Evaluation Report on HCFC Consumption Controls for European Countries, European Commission. For the European Commission Directorate-General Environment, Mr. Wagner manages this project reviewing the use of HCFCs under Article 5 of Regulation (EC) 2037/2000 and recommending to the Commission whether further adjustments to these HCFC consumption controls would be appropriate.

Stratospheric Protection Division, Program Benefits, U.S. EPA. Mr. Wagner managed the ICF team in their support of SPD on a quick-turnaround request to provide benefits of ODS emissions avoided, including those associated with developing country compliance with the Montreal Adjustments, the U.S. EPA's 608 Substitute Recycling Rule, and ODS destroyed. The benefits of emissions avoided were expressed in MMTCE, ODP tons, and ppb/Clx loading. ICF was able to respond to this request in a timely fashion because of the resources and systems in place, specifically the AHEF model, which is used to develop emissions projections to support SPD in assessing different policy scenarios, as well as the effectiveness of different regulations.

EMPLOYMENT HISTORY

ICF International, Consulting Senior Vice President, Vice President, Project Manager, Senior Chemist, Chemist, Staff Chemist	1986-Present
Technassociates, Inc., Technical Information Specialist	1984 – 1986
ICF Consulting, Research Assistant	1981 – 1983

PAMELA MATHIS

ICF INTERNATIONAL

EDUCATION

M.Sc., Environmental Science and Policy, Johns Hopkins University, Baltimore, Maryland, USA, 2003
B.A., Geography and International Development, McGill University, Montreal, Quebec, Canada, 1997

EXPERIENCE OVERVIEW

Ms. Mathis, a Project Manager at ICF International, has more than seven years of experience supporting EPA on economic and scientific issues related to international stratospheric ozone depletion and global climate change. Ms. Mathis is ICF's sector expert in MVACs, stationary refrigeration/air-conditioning, fire extinguishing, and other sectors that have historically relied on the use of ODS and have now transitioned to chemicals with high global warming potentials (GWP). She currently manages work to support EPA's Responsible Appliance Disposal Program—which seeks to ensure the proper disposal/recycling of ODS and GHG refrigerant and foam—as well as a project for the UN Multilateral Fund to review international systems and procedures in place to collect and destroy unwanted ODS contained in household appliances and in bulk. As part of these projects, Ms, Mathis visited appliance recycling facilities, refrigerant reclamation facilities, and ODS/GHG destruction facilities in the United States, Australia, and Japan. Over the years, she has also played a leading role in updating the refrigeration/AC and fire protection sectors of EPA's U.S. Vintaging Model, and in developing the international marginal abatement cost (IMAC) curve analyses for non-CO_2 high-GWP gases in those sectors for the EPA, the Australian Greenhouse Office, the International Energy Agency, and the California Energy Commission. Ms. Mathis is fluent in English and French, has a solid working knowledge of Spanish, and a basic understanding of Portuguese.

SELECT PROJECT EXPERIENCE

EPA's Responsible Appliance Disposal (RAD) Program, U.S. EPA, 2006-Present. Ms. Mathis has assisted EPA with the launch and implementation of a new voluntary program for municipalities, retailers, manufacturers and utilities, to promote the responsible disposal of refrigerated appliances, including refrigerators/freezers, window air-conditioning units, and dehumidifiers. The program seeks to ensure the proper disposal/recycling of ozone-depleting refrigerant and foam, greenhouse gas refrigerant, and hazardous materials, including PCBs, mercury, and used oil. To this end, Ms. Mathis researched the current state of appliance disposal/recycling in the U.S., as well as the costs to implement responsible programs that not only comply with federal laws, but go beyond. As part of this work, Ms. Mathis visited two major appliance recycling facilities in southern California and conducted interviews with company representatives. Ms. Mathis also managed the creation of partnership agreements, as well as a variety of outreach materials to educate stakeholders about the benefits of proper appliance disposal/recycling and recruit new partners—including PowerPoint presentations, fact sheets, and EPA web pages. In addition, she led the development of draft outreach strategies to engage new program partners, as well as a white paper on the cost-effectiveness of utility-run appliance recycling programs from an energy standpoint. Finally, Ms. Mathis managed the development of an Information Collection Request (ICR) for the RAD Program, an Excel-based reporting form for partners, as well as a report analyzing the costs and benefits of different implementation scenarios for RAD programs as part of an ongoing effort to gain approval of appliance recycling programs as Supplemental Environmental Projects.

Best Available Technologies and Practices for Minimizing Emissions of ODS, European Commission (2005). Ms. Mathis managed a study to identify the best available technologies and environmental practices concerning the prevention and minimization of leakages and emissions of ODS in connection with recovery, recycling, reclamation and destruction activities. To develop the report, Ms. Mathis managed the development and dissemination of questionnaires to Member State representatives and companies involved in the recovery, recycling, reclamation and destruction of ODS—namely those involved in halon recovery, halon system decommissioning, the servicing, maintenance, and

demanufacturing/decommissioning of refrigeration/air-conditioning equipment, and the destruction of ODS fluids and foams. Based on collected survey data, in addition to existing technical or other information, Ms. Mathis oversaw the analysis and assessment of best available technologies and best environmental practices, to help foster an improved understanding of available and superior options for handling ODS among industry and decision makers throughout the EU-25.

Assessment of Cost and Environmental Impacts of the California Appliance Early Retirement and Recycling Program (2002). For the Appliance Recycling Centers of America, Ms. Mathis assisted in an analysis assessing the most economically and environmentally efficient technology for destroying ODS in appliance polyurethane foam in California. Based on technical and economic feasibility, the report evaluated the technoligies for the destruction of polyurethane foams by estimating the total cost of destruction on two bases: cost per refrigerator destroyed and cost per pound of ODS destroyed.

Support for the U.S. Vintaging Model and Analysis of Phaseout Scenarios, U.S. EPA (2000-Present). Ms. Mathis has been responsible for the continued development and updating of the refrigeration/air-conditioning and fire protection sectors of U.S. EPA's Vintaging Model through reviews of new literature and working with EPA and members of industry to ensure that model assumptions of industry growth rates, market sizes, chemical use, and other parameters coincide with industry estimates. ICF uses the Vintaging Model to estimate emissions ODS substitutes for the national inventory report.

California Marginal Abatement Cost Curves, California Energy Commission (2006). Ms. Mathis assessed the feasibility and costs associated with HFC emissions reduction options in the refrigeration and air-conditioning sector in California. She developed California-specific GHG emission baselines for the refrigeration/air-conditioning sector through 2020 and was responsible for calculating the costs and emission reduction potentials associated with all options in that sector. She built Excel-based models to conduct the economic analysis and drafted the chapter on refrigeration/air-conditioning in the final report.

International Marginal Abatement Curves for High-GWP Gases, U.S. EPA (2003-2006). Ms. Mathis was involved in a project involving the forecasting of high-GWP gas emissions in all regions of the world and the assessment of the costs of potential options to mitigate such emissions. Specifically, Ms. Mathis was the lead analyst looking at emissions of HFCs and PFCs in the refrigeration/air-conditioning and fire extinguishing sectors, responsible for calculating costs for abatement options and conducting research on country-specific data on uses by sector as well as market penetration of alternatives. Ms. Mathis also helped create and run intricate models to determine the number of million metric tons of carbon equivalent (MMTCE) that may be reduced through 2020, as well as the break-even costs of each technology in each country, at various discount rates and tax rates.

Mitigation Analysis for High Global Warming Potential Emissions in Australia (2002-2003). For the Australian Greenhouse Office (AGO), Ms. Mathis evaluated the opportunities to reduce emissions of HFCs in the refrigeration and air-conditioning sector as well as other the industries regulated under the Montreal Protocol. Ms. Mathis designed and prepared surveys to be completed by Australian industry representatives. The analysis reports on the most appropriate and promising alternative technologies or gases that could be used within these industries, their likelihood and extent of future adoption, and their associated market barriers, including technical, safety, cost, or other impediments.

Analysis of International Marginal Abatement Curves for High-GWP Gases, International Energy Agency (IEA) (2002-2003). Ms. Mathis supported an international project involving HFC emissions projections world-wide and cost assessments of mitigation options at various discount and tax rates. Ms. Mathis served as the sector lead on refrigeration/air-conditioning and fire extinguishing sectors. She conducted research on assumptions of HFC emissions, cost of abatement options, and technical applicability of abatement options. She was also responsible for quality assurance of model output.

Domestic Cost Curves for High-GWP Gases, U.S. EPA (2001-2002). Ms. Mathis was involved in addressing the costs of potential options to mitigate emissions of HFCs and PFCs from 10 sectors in the United States. Specifically, she was the lead for both the refrigeration and air-conditioning, and fire-suppressant chapters. Ms. Mathis analyzed the most technologically- and economically-viable options available to reduce emissions in these sectors, conducted market research to project future market share penetrations, and ran models to determine break-even costs of each technology.
Continuing Uses of ODS in the United States (2006). For the U.S. EPA, Ms. Mathis managed an analysis characterizing actual and potential continuing uses of ODS in the United States. The analysis focused on continuing ODS use in the military, as well as the aerospace, civil aviation, and commercial shipping industries. The report estimated amounts of ODS (by type) installed in equipment, annual quantities required, stockpiles available, new chemical required, likely phaseout dates, potential alternatives, and barriers to the transition away from ODS.

Study on the Collection and Destruction of Unwanted ODS in Appliances and Bulk ODS, Multilateral Fund Secretariat and United Nations Office in Nairobi (2007-Present). Ms. Mathis is collecting information on successful the systems/procedures in place for collecting and destroying unwanted ODS contained in appliances and stored in bulk in order to develop guidance for developing countries to establish appropriate management systems for the treatment of unwanted ODS. To this end, Ms. Mathis has led the development of surveys and will be conducting in-country visits to Australia and Japan. Other country visits will also be conducted to Canada, the Czech Republic, Germany, Japan, the UK, the United States, India, and Colombia.

Halon Installed on EU-Flagged Commercial Ships and Military Aircraft, European Commission (2004-2005). Ms. Mathis managed a project to determine the amount of halon contained on EU-flagged ships flagged to the 25 Member States in the EU, and the amount of halon 2402 contained in military aircraft in the 15 Member States that existed in the EU on 1 January 2004—both of which are prohibited. To this end, Ms, Mathis managed the undertaking of data transfer with Lloyd's Registry, as well as the development and dissemination of a short survey to military representatives of EU-15 Member States. Ms. Mathis also managed the development and finalization of a final report.

Review of Critical Uses of Halon Specified in Annex VII of Regulation (EC) No 2037/2000 on Substances that Deplete the Ozone Layer, European Commission (2006). For the Commission Directorate-General of the Environment, Ms, Mathis co-managed a review identifying and assessing technical and economic alternatives or technologies to halon critical uses, with a strong focus on military uses of halon. To understand the specific platform types on which halon is used, and the applications for which it is used for, Ms. Mathis lead the development of complex surveys disseminated to Member State military representatives. The surveys also solicited information regarding feasible or potentially feasible alternatives to halon, by application, as well as expected phaseout timeframes, under a business-as-usual scenario. Based on this information, the report recommended a new, better defined list of critical uses for halon, with recommended phaseout dates for each application. The results of the study will allow the European Commission to develop a new Annex VII, in collaboration with Member States, and set phaseout dates for each halon application so that ODS emissions can be minimized.

Review and Evaluation of Minimum Qualification Requirements and Programmes for Leak Reduction, Recycling, Recovery, Reclamation, and Destruction of F-Gases and ODS in the European Union, European Commission (2004-2005). Ms. Mathis managed the review and evaluation of the measures taken by Member States and their associations regarding the minimum qualifications requirements and programmes (e.g., training or courses) for personnel involved in reducing leaks, recycling, recovering, reclaiming, and destroying controlled f-gases and other ODS. As part of the evaluation process, questionnaires were developed for data collection from associations and organisations within the Member States pertaining to minimum qualification requirements and programmes offered. The sectors included in this analysis are stationary refrigeration/AC, solvents, fire protection, motor vehicle air conditioning, and high and medium voltage equipment containing SF_6.

Development of Technical Leak Inspection Templates for Reducing F-Gas Emissions from Refrigeration/AC and Fire Extinguishing Equipment (2005-2006). For the European Commission, Ms. Mathis managed a project to establish technical leak inspection requirements for refrigeration/AC/heat pump equipment and fire protection systems that contain fluorinated greenhouse gases. To develop the report, ICF developed and disseminated a survey to Member State and industry representatives, to solicit information on leak inspection practices and costs. The report was designed to ensure that leakage (emissions) of f-gases from equipment is reduced through proper leak inspection.

Design of Reporting Format for Compilation and Analysis of Data Reported by Companies for the Import, Export, and Production of Certain Fluorinated Greenhouse Gases (F-gases) (2006-2007). For the European Commission, Ms. Mathis managed the development of reporting forms and a statistical fact sheet for aggregated input of data reported by companies involved in the import, export, and/or production of regulated f-gases in the European Union. In order to ensure that all companies required to submit annual reports (beginning in 2008) are informed of their obligation to report, ICF collected an exhaustive list of relevant companies and contact information. To this end, ICF has obtained trade data for the regulated substances and is surveying trade associations and member state representatives to obtain a comprehensive list of companies and contact information. ICF developed Excel-based reporting forms, a summary form, and a statistical fact sheet for the rapid compilation of reported data and display of key facts and trends.

Barriers to the Transition Away From Halons in Civil Aviation Applications, U.S. EPA (2004). In coordination with subcontractor, Hughes Associates, Ms. Mathis prepared a report for EPA outlining the barriers to the transition away from halons in the civil aviation sector. Specifically, the report assesses the current status of halon replacement in lavatory trash receptacle protection, handheld extinguishers, engine nacelles/auxiliary power units, and cargo compartments. For each of these civil aviation applications, the report explains and evaluates the current Minimum Performance Standards (MPS), describes the agents tested to the MPS, identifies the status of halon replacement, and assesses the barriers to halon replacement. The report also presents recommended actions and assesses various regulatory options to expedite the halon phaseout.

Changes in HCFC Consumption and Emissions from the U.S. Proposed Adjustments for Accelerating the HCFC Phaseout, U.S. EPA (2007). Ms. Mathis recently supported EPA in a series of quick-turn around analyses with regards to an evaluation of a number of different policy options proposed by the United States for accelerating the HCFC phaseout in Article 5 and non-Article 5 countries. This analysis required the development of consumption baselines and projections through 2040 for A5 and Non-A5 countries, followed by the development of consumption scenarios for each element of change (and element combinations) involved in the proposed policy change. Ms. Mathis supported the development of a methodology and estimated the potential climate and ozone impacts of seven policy options within less than a one week timeframe. Additional rapid-response updates to the methodology and the report were subsequently added over a period of four months. Such additions included the estimation of HFC-23 production caused by HCFC-22 consumption, offsetting effects of consumption of high-GWP substitutes, and estimation of energy efficiency gains (and associated reductions to CO_2 emissions) caused by premature replacement (early retirement) of HCFC-charged equipment.

ODS Destruction Report (2006-Present). Ms. Mathis managed the research and preparation of a report on ODS destruction that contained the following information: (1) U.S. and international regulations and policy regarding ODS destruction; (2) U.S. and international facilities that destroy ODS and amounts of ODS destroyed in the U.S.; (3) emissions associated with ODS destruction and whether U.S. destruction facilities could meet the Montreal Protocol recommended efficiency and emissions criteria for ODS destruction; (4) projections of the future amounts of ODS available for destruction and whether U.S. facilities would have the capacity to destroy this ODS; and (5) costs of ODS transportation and destruction. The report will be used by the U.S. EPA to identify what, if any, regulatory changes are

needed to ensure that ODS are being fully and safely destroyed in the United States, and that adequate capacity exists to handle future amounts ODS destined for destruction.

Costs and Benefits of CAAA Section 609 Requirements (2007). For the U.S. EPA, Ms. Mathis estimated the emission reductions and costs associated with CAAA Section 609 Requirements. This involved a detailed assessment of the number of R-12 MVACs on the road, the number of R-12 retrofits performed, the MVAC refrigerant charge remaining at service and disposal, actual recovery practices at service and disposal, and actual recovery efficiencies for recovery/recycling and recovery-only devices. Knowledge and expertise gained through these analyses has been used to improve Vintaging Model accuracy in this sector.

Assessing the Scope of and Servicing Needs of Equipment using HCFCs in the United States (2004-Present). For the U.S. EPA, Ms. Mathis is supporting an analysis on the U.S. air conditioning and refrigeration industry to determine the projected quantities of HCFC refrigerants needed to service equipment charged with HCFCs manufactured prior to 2010 that will still be in use after 2010. Ms. Mathis has supported data collection efforts to gather current and future market sizes of different equipment, specifications of charge size and quantities of refrigerant consumed to service such equipment, and anticipated trends in recycling and reclamation of refrigerants. The findings from this analysis will aid EPA in preparing for the future HCFC phaseout dates and the allocation of future consumption caps to U.S. industries.

International Workshop to Phaseout Ozone-Depleting Refrigerants in Developing Countries (2006-Present). For the European Commission's Directorate-General for Research, Ms. Mathis is playing a lead role in the organization of an innovative international workshop to target the reduction of HCFC consumption in developing countries between now and 2015. The workshop will provide developing country stakeholders with the technical tools needed to phaseout HCFCs (e.g., information on viable alternatives, technology transfer, funding opportunities) and will target consensus-building among stakeholders on an intermediate phaseout schedule to be implemented under the Montreal Protocol prior to 2040. This work will involve close collaboration with high-level stakeholders across country governments and multilateral organizations, including the World Bank, UNEP, UNDP, and UNIDO.

Review of the Supply and Demand of Recycled HCFCs for Use in Existing Refrigeration/Air-Conditioning Equipment Beyond 2009 (2006). For the European Commission, Ms. Mathis managed the review of the technical feasibility, economic cost, and environmental impact of phasing out HCFCs in the EU-25 plus Bulgaria and Romania. The analysis estimates the supply of and demand for HCFCs to service existing refrigeration equipment in each country, and projects of how these factors vary in three phaseout scenarios—which include the existing phaseout schedule, an advanced phaseout, and an extended phaseout schedule. The results of the study will be submitted to the European Parliament and the Council, which decide whether to alter the current scheduled phaseout date of 2015. This project involved complex modelling and analytical work to build up HCFC demand, requiring data on equipment stock, charge size, leak rate, and lifetime—by end-use, by HCFC type, and by country. Similarly, the supply component of the model required complex inputs on amount of charge recoverable at end of life and percent of refrigerant reclaimable/reusable (considering refrigerant contamination and access to reclamation facilities) throughout the EU-25. To obtain this complex array of inputs, surveys were developed and disseminated to industry stakeholders and Member State representatives. The information obtained through the survey responses served as the basis for the study.

EMPLOYMENT HISTORY

ICF International: Project Manager, Senior Associate, Associate, Analyst	2000–Present
National Academy of Sciences: Project Assistant	1999–2000
The Social Justice Committee, Canada: Assistant Program Coordinator	Winter/Spring 1999

Private Law Practice, Canada: Legal Assistant (PT)	Winter/Spring 1999
Inter-Church Committee on Human Rights in Latin America, Canada: Researcher/Author	1997-1998
Fundacion Moises Bertoni, Paraguay: Assistant Project Coordinator	Summer 1996
Jane Goodall Institute, Canada: Environmental Educator	1995-1996

MARIAN VAN PELT

ICF INTERNATIONAL

EDUCATION

M.S., Atmospheric Science, University of Arizona, 1998
B.S., Physical Sciences, University of Maryland, 1992

EXPERIENCE OVERVIEW

Ms. Van Pelt is a Principle Manager with ICF, and has been with the firm for 9 years. She has 14 years of experience conducting research, performing environmental analyses, supporting national policy, and developing models related to climate change and stratospheric ozone depletion. She has provided technical support to the U.S. EPA in the areas of emissions modeling, developing emission estimates for the U.S. GHG inventory, tracking emissions of ozone-depleting chemicals, and developing marginal abatement cost curves. Since 1999, Ms. Van Pelt has been the lead coordinator in support of the development of EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks, responsible for generating emission estimates from numerous industrial sources, in addition to aggregating all the data and creating the final Inventory document. She is an internationally recognized expert in industrial process GHG emissions and in overall GHG emission inventories. She has also conducted a variety of national and international analyses focused on GHG emission inventories, and evaluating the emissions and reduction opportunities of engineered chemicals (HFCs, PFCs, and SF_6).

SELECT PROJECT EXPERIENCE

Inventory Preparation, U.S. EPA (1999-Present). Ms. Van Pelt is the ICF lead for preparing EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks. This document serves as the baseline for U.S. GHG emissions from 1990 forward. Ms. Van Pelt is responsible for managing the development of emission and uncertainty estimates for carbon dioxide from the burning of fossil fuels (which accounts for the vast majority of U.S. GHG emissions), emissions of substitutes for ozone depleting substances, and CO_2 emissions from industrial processes. In addition to developing emission estimates from individual sources, Ms. Van Pelt is responsible for bringing the full Inventory document to completion annually, coordinating emission estimates from all sources, developing national summary statistics, evaluating emission trends over the Inventory period, and supporting a variety of Inventory-related analyses, including participating in international reviews of the Inventory document and data. As the Inventory coordinator at ICF, Ms. Van Pelt manages the overall Inventory schedule, ensures that the Inventory report conforms to international reporting requirements, manages the Inventory data, designs and manages the Inventory QA/QC process, identifies key source categories, edits the final Inventory, and manages the layout and publication of the full color Inventory document. In addition, Ms. Van Pelt coordinates the annual public and expert reviews of the Inventory and implements a strict quality control and quality assurance program throughout the Inventory development process.

Vintaging Model for Tracking Ozone Depleting Substance Emissions, U.S. EPA (1998-Present). Ms. Van Pelt is responsible for the continued development of EPA's Vintaging Model, used for estimating use and emissions of various ozone depleting substances (ODS) and ODS substitutes. Ms. Van Pelt updates this model regularly by working with EPA and members of industry to ensure that model assumptions of industry growth rates, market sizes, chemical use, and other parameters coincide with industry estimates. Output from this model also supports analyses of the health impacts of stratospheric ozone depletion, and allows for development of "what-if" scenarios to help steer policy decisions about ozone depleting substances. Ms. Van Pelt helps EPA monitor the estimated use and emissions of the substances toward meeting U.S. obligations under the Montreal Protocol. Emission estimates from this model are used to estimate and project high global warming potential (GWP) emissions from substitutes for ODS.

International Marginal Abatement Cost Curves (IMAC) for High-GWP Sources, U.S. EPA (2001-2006). Ms. Van Pelt led a study of international options for reducing emissions of high-GWP gases from all industrial sources. As part of this analysis, Ms. Van Pelt developed baseline emission estimates for every country in the world for every high-GWP source. Additionally, Ms. Van Pelt analyzed opportunities to reduce emissions, and how those opportunities, their cost, and their acceptability vary from country to country, or region to region. The result of the analysis was a comprehensive IMAC for high-GWP gases.

Marginal Abatement Cost Curves for Non-CO_2 Gases, California Energy Commission (2004-2005). Ms. Van Pelt developed baseline and projected emission estimates of high-GWP gases for the state of California and identified the costs and market potential of emission reduction practices and technologies. The analysis contributed to an overall California MACC for non-CO_2 GHGs.

Domestic MACC for High-GWP Sources, U.S. EPA (1998-2001). Ms. Van Pelt assisted in analyzing options to reduce high-GWP gas emissions from domestic industrial sources. This work involved developing baseline emission estimates for each sector and identifying emissions reduction or abatement technologies, identifying the extent to which they could reduce emissions, and developing cost estimates for each technology. This analysis allowed policymakers to determine which options are most viable, from an economic and emission reduction perspective. She contributed to the report entitled *U.S. High-GWP Gas Emissions 1990-2010: Inventories, Projections, and Opportunities for Reductions.*

Development of State Inventory Tools, U.S. EPA (2002). Ms. Van Pelt assisted in the development of a set of tools designed to assist states in developing state-level GHG emissions inventories. She managed the development of a tool for estimating emissions from industrial processes, which includes emissions of CO_2, CH_4, N_2O, and the high-GWP gases. The tool follows the state guidance for industrial process sources if they exist, or develops methodologies to estimate emissions on the state level that generally corresponds to the UNFCCC guidelines for national inventories. In addition, she is assisting with the update of Emissions Inventory Improvement Program guidance to states on developing inventories.

Support to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat (Fall, 2002). Ms. Van Pelt is a nominated expert in industrial process and general inventories to the UNFCCC inventory review process. In this capacity, she provided inventory review and overall data management support for the UNFCCC Secretariat. She reviewed the industrial processes sections of inventories from Spain, New Zealand, United Kingdom, and the Czech Republic. Additionally, she was invited to review the Secretariat's management of the data received from annual inventory submittals from every country under the UNFCCC, and provided input on the development of the new CRF Reporter software.

Development of Emission Estimates for Substitutes for Ozone Depleting Substances, U.S. Environmental Protection Agency (1998-Present). Ms. Van Pelt is responsible for applying the Vintaging Model to develop baseline emission estimates and projections of high global warming potential substitutes for ozone depleting substances (ODS). Ms. Van Pelt supports the EPA's Significant New Alternatives Program, a program that identifies acceptable alternatives to ODS in the United States, by providing routine estimates of emissions abated to date that can be attributed to the program. Additionally, Ms. Van Pelt manages models and other tools that can provide emission projections under a variety of plausible scenarios, which can be used to track progress toward meeting future program or policy goals. Ms. Van Pelt develops emissions data in support of the U.S. greenhouse gas emissions inventory, domestic and international marginal abatement analyses, and a variety of related projects.

Common Reporting Format Tables, U.S. Environmental Protection Agency (2000-Present). Ms. Van Pelt is the lead support contact for the development of the CRF tables for the U.S. Inventory. Each year, the process includes aggregating emission estimates, activity data, and emission factors, plus explanatory text, into the rigorous structure of the CRFs. Ms. Van Pelt manages the incorporation of all data and the implementation of a variety of quality control procedures to ensure that the CRF tables report data that matches the National Inventory Report. For the April 2006 Inventory submission, Ms. Van Pelt managed

an intensive effort to convert the US inventory spreadsheet system into a format required under the new UNFCCC CRF Reporter software. In developing the macros and system for populating the Reporter software, Ms. Van Pelt's team will help the US become one of the first countries to automate this process.

U.S. Climate Action Report, U.S. Environmental Protection Agency (Fall, 2001). Ms. Van Pelt supported preparation of a chapter on U.S. GHG emission estimates for the U.S. Climate Action Report, the third National Communication of the United States under the United Nations Framework Convention on Climate Change, based on data and analysis prepared for the Inventory of U.S. Greenhouse Gas Emissions and Sinks.

ODS Destruction Project Development, U.S. Environmental Protection Agency (2005-Present). Ms. Van Pelt is supporting the development of an offsets project designed to characterize baseline project and alternative scenario ODS emissions for an ODS destruction project. The result of this project will be a protocol that can be used to characterize emissions reduced by ODS destruction facilities.

Greenhouse Gas Emissions Database, U.S. Environmental Protection Agency (2002-Present). Ms. Van Pelt is supporting the development, population, and management of a GHG emissions database, which contains emissions data, both historical and projected, for all greenhouse gas emission sources and gases, for every country. As part of this work, Ms. Van Pelt managed the development of U.S. emission estimates from every source for the years 1850 through 2000. Continuing efforts to improve the GGED include the addition of socioeconomic data and the capability to generate complex queries.

Support for National Systems in Central America, U.S. EPA (2004-Present). Ms. Van Pelt is contributing to a project that is building capacity in Central American countries to develop and maintain national systems for GHG emission inventory development. This project involves developing templates for institutional arrangements, source category methodologies, identification of key sources, and inventory improvements that can be combined into country specific national systems reports.

HCFC Workshops for Developing Countries to Consider early Phase-Out of ODS, European Commission (Present). Ms. Van Pelt is managing an international workshop to help developing countries consider the early phase-out of ODS. The workshop will convene international experts in refrigeration/air-conditioning, foam blowing, aerosol manufacturing, solvent use, and fire protection, together with representatives from international development organizations and government representatives from both developed and developing countries. An aim of the workshop is to facilitate technology transfer of processes and equipment that use non-ODS alternatives, as well as alternatives that do not rely on HFCs and PFCs.

Assessing the Scope of and Servicing Needs of Equipment using HCFCs in the United States, U.S. Environmental Protection Agency (2004-Present). For the U.S. EPA, Ms. Van Pelt is leading the efforts to develop different modeling simulations using EPA's Vintaging Model for an analysis on the U.S. air conditioning and refrigeration industry's projected demand of HCFC refrigerants needed to service equipment manufactured prior to 2010 that will still be in use after 2010. She served as a lead technical editor for the preliminary draft report, released in a Federal Register Notice of Data Availability (NODA) November 2005, and for the revised report prepared for EPA's stakeholder meeting on the topic in September 2006. The findings from this analysis will aid EPA in preparing for the future HCFC phaseout dates and the allocation of future consumption caps to U.S. industries.

Review of Technical and Economic Availability of Feasible Alternatives to Recycled HCFCs in Existing Refrigeration Equipment, European Commission (2006). Ms. Van Pelt is assisting in a study of the technical feasibility, economic cost, and environmental impact of alternatives to HCFCs. The review will estimate the supply and demand for HCFCs to service refrigeration equipment in each Member State and project how these factors vary in three phaseout scenarios. The results of the study will be submitted to the European Parliament and the Council, which decide whether to alter the current scheduled phaseout date. Ms. Van Pelt is managing the development of a projections tool that identifies existing stocks of HCFC-containing equipment and projects the supply and demand for HCFCs under alternative scenarios.

Third Overall Performance Study (OPS-3) of the Global Environment Facility (GEF), World Bank (2004-2005). Ms. Van Pelt provided management and technical support to a study to assess the extent to which the GEF has achieved, or is on its way towards achieving, its main objectives, with a focus on program/project outcomes, the sustainability and replicability of those outcomes, and progress toward impacts. More specifically, through a review of existing GEF literature and data, as well as on-the-ground interviews and data collection in approximately 15 countries, the Study aims to: (a) provide an overall assessment of the impacts and other results achieved since the GEF restructuring in 1994 until June 2004; (b) assess the effectiveness of GEF policies, strategies and programs; (c) examine the main factors influencing the achievement of GEF objectives, and consider possible shortcomings to the achievement of objectives; (d) develop key lessons and provide clear and actionable recommendations to the GEF Council on how to render GEF support more effective in contributing to global environmental benefits. Ms. Van Pelt helped organize the evaluation process, field visits, and desk studies, and played a key role in assessing GEF's performance in the areas of biodiversity, climate change, international waters, POPs, ozone depletion, and effects of institutional structure and process on the results of the GEF.

ODS Substitute Emissions Estimation Tool, Australian Greenhouse Office (AGO) (2003-2004). Ms. Van Pelt developed a tool for the AGO that estimates emissions of high-GWP gases from ODS substitutes sources for their annual inventory report. The tool outputs data in a format required for the CRF tables.

Review of the Performance of the Financial Mechanism of the Montreal Protocol, United Nations Office in Nairobi (2004). Ms. Van Pelt was a lead advisor to a major performance evaluation of the Multilateral Fund of the Montreal Protocol. The project included the development of observations and recommendations for operations and management in 23 key organizational evaluation areas. The ICF review team was charged with evaluating disparate issues including the efficiency and efficacy of the administrative structure of the MLF, the efficiency of the project review and approval processes, and the appropriateness of Fund management practices by the Implementing Agencies and the Fund Treasurer.

Analysis of Alternatives for Substitutes for Ozone Depleting Substances, Australian Greenhouse Office (2002). Ms. Van Pelt supported the AGO in reviewing the options for reducing ODS substitute high-GWP source emissions within Australia. Work involved surveying industry representatives within the country to determine industry attitudes toward the use of alternatives, and identifying those alternatives that have significant potential to reduce such high-GWP gases.

SELECTED PUBLICATIONS AND PRESENTATIONS

Martin, M., Dickinson, R.E., and Yang, Z-L. Use of a coupled land surface general circulation model to examine the impacts of doubled stomatal resistance on the water resources of the American southwest. Journal of Climate. December 1999.

Van Pelt, M., et al. Development of an International Marginal Abatement Curve of High Global Warming Potential Gases. Non-CO_2 Greenhouse Gases: Scientific Understanding, Control Options and Policy Aspects. Millpress 2000.

Godwin, D., M. Van Pelt, K. Peterson. Modeling Emissions of High Global Warming Potential Gases from Ozone Depleting Substance Substitutes. Presentation and paper at Earth Technology Forum. April 2003.

PROFESSIONAL AFFILIATIONS

Member, American Meteorological Society

EMPLOYMENT HISTORY

ICF International: Project Manager, Senior Associate, Associate	1998–Present
University of Arizona: Research Assistant	1995–1998
Science Applications International Corporation: Environmental Scientist	1992–1995

ICF INTERNATIONAL

DUNCAN ROTHERHAM

EDUCATION

Graduate Diploma, Ecotoxicology, Concordia, Quebec, Canada, 1997
B.Sc., Biology, University of Victoria, British Columbia, Canada, 1995

EXPERIENCE OVERVIEW

Duncan Rotherham is a Principal with ICF International working in the Energy Group's Energy Markets Practice. He has ten years experience providing a wide range of services to the North American and International oil and gas, electricity/gas utility, aluminum and metals, forest products, manufacturing, and chemical sectors. Of relevance to this endeavor Mr. Rotherham has supported DuPont since 1999 in their high-GWP abatement projects in the areas of N_2O from Adipic and Nitric Acid facilities and HFC-23 from HCFC-22 production facilities. Duncan is very familiar with Adipic and Nitric Acid production facilities having visited 3 North American facilities annually since 1999 to audit emission reduction claims. Internationally, he has supported the development of Project Design Documents for the Adipic (2) and Nitric N_2O (3) abatement project developers in the Clean Development Mechanism and Joint Implementation. All these projects required a detailed understanding of the production process, data management and abatement technologies.

Duncan has successfully developed and implemented greenhouse gas emission management systems at both the corporate (entity) level client as well as emission reduction project proponents. He has developed and deployed strategies for operating under evolving market based mechanisms (emissions trading) for companies in a diversity of industrial sectors (chemical, oil and gas, utility, aluminum, forest products, manufacturing). Mr. Rotherham has worked with over 40 companies to assess current emissions management systems, identify gaps, develop robust inventories, implement transparent operating procedures, and tools. Duncan has also assessed emission abatement options, developed coordinated multi-pollutant emission reduction strategies, supported the development of marginal abatement cost curves (MACs), and quantified carbon risk.

Mr. Rotherham has aided large final emitters and project developers interested in identifying and executing emission reduction projects for the purpose of participating in emissions trading. In North America Duncan has supported dozens of transactions (on the buy and sell side) in the voluntary space including bilateral transactions, Chicago Climate Exchange (CCX), Emission Resource Trust's (ERT) GHG Registry, Voluntary Climate Registry (VCR). Similarly for projects under the clean development mechanism (CDM) he has managed the development and implementation of baselines, protocols development, and undertaken feasibility studies and risk assessments in the areas of high-GWP (N_2O, PFC and HFC-23) gas abatement, landfill gas recovery, fuel switching and sequestration. For the past year Duncan has worked as advisor to the Industry Provincial Offset Group – a group of industrial (20) and provincial stakeholders – to consensus build, prepare documentation, and communicate/lobby the Canadian Federal government on the issues surrounding offset providers and buyers.

Duncan leads ICF International Canada Inc's audit business and has carried out over 30+ audits of emission reduction / offset projects in the US and Canada. Specifically, he has carried out audit in the landfill gas sector (CH_4 capture and combustion), geological sequestration (acid gas capture and enhanced oil recovery), renewable power, as well as energy efficiency and transportation. Duncan has acted as an auditor in support of bp's (formerly BP Amoco's) project to verify their 1990, 1999 and 2000 inventories of GHG emissions. For the past seven years he has lead the ICF team's efforts aimed at verifying emissions reduction projects at DuPont's North American facilities (HFC-23 abatement) and for Invista Canada (N_2O abatement from Adipic).

Duncan Rotherham is a lead auditor with extensive auditing experience in the private sector. He has designed, built, deployed and audited environmental management systems and processes for many major corporations including Sunoco, Ontario Hydro Nuclear, Ontario Power Generation, SaskPower, Manitoba Hydro, Tembec and CXY Chemicals.

SELECT PROJECT EXPERIENCE

High-GWP

Development of a CDM-PDD for N_2O abatement Project at Adipic Acid facility in China, Multinational Chemical Company (2003-2006). Duncan Rotherham led ICF International's efforts in cooperation with a large multinational chemical company and a Chinese partner to develop a Project Design Document (PDD) for submittal to the CDM. Duncan developed the PDD (including monitoring, data collection and retention, and verification plans) and supported the project proponents through the host country approval process and third party validation. The project is aimed at implementing N_2O abatement technology at a Chinese Adipic Acid facility. The PDD includes all CDM required elements of project description, baseline case, and monitoring plan.

Development of a CDM-PDD for N_2O abatement Projects at Nitric Acid facility in India, Private Carbon Fund (2006-2007). Duncan Rotherham led ICF International's efforts in cooperation with a 500 million dollar C-Fund and an Indian partner to develop a Project Design Document (PDD) for submittal to the CDM. Duncan developed the PDD (including monitoring, data collection and retention, and verification plans) and supported the project proponents through the host country approval process and third party validation. The project is aimed at implementing N_2O abatement technology at an Indian Nitric Acid facility. The PDD includes all CDM required elements of project description, baseline case, and monitoring plan.

Verification of GHG Emissions Reductions for Emission Reduction Projects, DuPont/Inista Canada (1999-Present). Duncan Rotherham led the ICF International team in the planning, undertaking and report writing of the verification of emission reductions associated with emission reduction projects at 3 of Dupont's North American facilities. The projects included nitrous oxide emission reductions at Dupont's Sabine Texas and Brockville Ontario plants (since sold to Invista) and HFC-23 emission reductions at the Louisville Kentucky plant. As no accepted standard was available for the verification of emission reductions at the project level ICF International developed their own approach based on the best available practices.

Development of a CDM-PDD for high-GWP (HFC-23) Projects in China and India, Multinational Chemical Company (2003-2006). Duncan Rotherham led ICF International's efforts in cooperation with a large multinational chemical company and a Chinese partner to develop a Project Design Document (PDD) for submittal to the CDM. Duncan developed the PDD (including monitoring, data collection and retention, and verification plans) and supported the project proponents through the host country approval process and third party validation. The project is aimed at implementing HFC-23 abatement technology at a Chinese facility. The PDD includes all CDM required elements of project description, baseline case, and monitoring plan.

Emissions Baseline Inventory / MVP Protocol Development

Development of a CDM-PDD for high-GWP Projects in China and India, Multinational Chemical Company (2003-2005). Duncan Rotherham led ICF International's efforts in cooperation with a large multinational chemical company and a Chinese partner to develop a Project Design Document (PDD) for submittal to the CDM. Duncan developed the PDD (including monitoring, data collection and retention, and verification plans) and supported the project proponents through the host country approval process and third party validation. The project is aimed at implementing HFC-23 abatement technology at a Chinese

facility. The PDD includes all CDM required elements of project description, baseline case, and monitoring plan.

Emissions Protocol Development and Baseline Verification, Alcan (2000). Mr. Rotherham developed an emission protocol and defined a baseline to verify GHG emissions and associated reductions for Alcan's Kitimat primary aluminum production facility. The protocol was being applied to the existing data at Kitimat to determine its robustness relative to the preferred reporting format. This comparative analysis resulted in recommendations concerning the utility of the existing database. The protocol was then be used to establish the baseline for the PFC emission reduction project and as the basis for the Emission Reduction Credit Creation Report and opinion letter to substantiate the creation of the credits.

Project Document Development for Acid Gas Injection Project. Duncan Rotherham led a team (ICF, client and verifier) in the development of an project document for a CO_2 sequestration project in Canada. The emission reduction project involved CO_2 capture from the Kwoen gas upgrader facility and re-injection / storage at the depleted Pardonet-Baldonnel reservoir. ICF was tasked with developing the quantification methodology and developing an verifiable monitoring campaign required to substantiate the claim of CO_2 reductions associated with the project. This involved working with process engineers in the identification of all sources of GHG emissions and the documentation of monitoring required to substantiate the ongoing integrity of the reservoir and volume of CO_2 delivered and sequestered.

Well-to-Wheels" (WTW) comparison of Greenhouse Gas emissions (GHGs) from Shell Oil Sands. Shell Canada contacted ICF to develop a "Well-to-Wheels" (WTW) comparison of Greenhouse Gas emissions (GHGs) from Shell Oil Sands and competing crude oil imports into the Untied States in 2010 and 2020. The main study objectives of the WTW analysis included;

The development of a transparent and defensible methodology to quantify and compare the greenhouse gas emissions from producing, transporting, refining and combusting transportation fuels (and refining by products) from Shell's proposed oil sands expansions with commercially-available alternative crude oils imported into the United States in both 2010 and 2020. This aligns with Shell's commitment to their Climate Change Advisory Panel.

The development of a robust analysis which Shell can use as part of its process to determine GHG commitments for its planned oil sands expansions.

The delivered report set out the objectives, methodology, key assumptions, and outputs of the Well-to-Wheels (WTW) comparison of Greenhouse Gas emissions (GHGs) from Shell Oil Sands and competing crude oil imports into the Untied States in 2010 and 2020. This WTW study is an input to the establishment of a Greenhouse Gas Management Plan for Shell's expanded Oil Sands operations, and is intended for use in public/stakeholder consultations on the voluntary climate change-related commitments that Shell will adopt. A set of marker crudes were identified - and their emissions intensity quantified - on the basis of commercial model projections for crude imports into US PADD II in 2010 and 2020 that would be displaced by Shell's Synthetic Crude Oil product (SCO): Saudi Extra Light, Saudi Light, Canadian Mineable Oilsands, and Canadian In Situ Oilsands. Mayan Heavy was added to provide a Heavy Oil marker, though it was decided not to include this marker in the public presentation because it is not actually displaced by the Shell SCO. The GHG intensities were quantified for production, transport, refining and combustion and compared to the Shell SCO for input into the Shell Canada voluntary GHG target setting process.

2000, 2002, 2004 GHG Inventory for Natural Gas Downstream, CEPEI (2001-2005). ICF International was commissioned to collect and compile 2000, 2002, and 2004 vintage GHG emissions data from the more than 10 participating companies. ICF developed inventory reports and statements of greenhouse gas (GHG) emissions for those years. The annual updates ensure continuing changes in the natural gas

transmission and distribution industry are accounted for in the inventory of emissions. Mr. Rotherham was the program manager and was responsible for data analysis and report write-up.

Emissions Inventory Assessment Revisions and Protocol Development, JD Irving (2000-2001). Duncan Rotherham worked with JD Irving to meet their greenhouse gas (GHG), nitrogen oxides (NO_x) and sulphur dioxide (SO_2) emissions management needs for their Irving Forest Products division. The Forest Products division manufactures pulp, tissue, paper and corrugated medium from its six pulp mill operations in New Brunswick (4), the US (1) and Ontario (1). ICF International developed a baseline (1990) and annual inventories (years 1991 through present) for GHG and current baselines for NO_x and SO_2 emissions given the probability of their near term regulation. ICF International developed a multi-pollutant protocol for the efficient and accurate quantification of emissions. The over all objective of the project was to ensure that the data being collected is comprehensive and accurate so that past (for GHG) and future emission abatement projects implemented at the pulp mills will yield GHG, NO_x and SO_2 emission "assets" marketable upon the implementation of a provincial, national or international emissions trading scheme.

Greenhouse Gas Inventory Assessment and Protocol Refinement, Nexfor (1999-2000). Mr. Rotherham examined the existing greenhouse gas (GHG) data set and measurement methodologies for Nexfor, a forest products company, to determine if they have been adequately structured, documented and measured to accurately quantify and qualify for future credits. Based on this assessment, ICF offered an opinion on the existing GHG measurement and reporting protocol and identified opportunities for improvement in measurement methodologies and reduction of associated uncertainty.

Emissions Inventory Development, Algonquin Power Corp., Primary Power Inc, and the Clean Power Income Fund (1999-2003). Mr. Rotherham and his colleagues conducted a detailed operations assessment, and prepared a comprehensive emissions inventory encompassing all the GHG, nitrogen oxides (NO_x), and sulphur dioxide (SO_2) emissions from Algonquin Power Corporation's small hydroelectric generation stations in Canada and the US and Primary Power Inc.'s biomass fired generating stations. The emissions baselines and inventories were developed in accordance with guidelines of the government registry programs: Voluntary Challenge Registry (VCR) in Canada and Climate Wise in the US. This process is integral in applying for and achieving recognition as a green power provider under the Environmental Choice Program's EcoLogo. Based on the inventory he undertook a detailed analysis of the identified assets and identified opportunities for gaining market recognition.

Greenhouse Gas Emission Measurement and Coverage for Entity Reporting Study, Environment Canada (1999-2000). Mr. Rotherham and his team completed a study for Environment Canada to identify the greenhouse gas (GHG) emission sources that can be measured/estimated at the entity level (e.g., corporate, institutional, facility), as contrasted with the top-down national inventory. This project's focus was on entity-level greenhouse gas (GHG) emission estimation and reporting, which required an operational/sectoral approach to building practical credible reporting guidelines. Entity level GHG emission measurement must account for the complexity in boundaries, process estimation methods, data availability, measurement techniques, ownership patterns, and temporal effects on baselines and annual estimating/reporting. The report was written to assist Environment Canada to eventually prepare comprehensive guidance for entity level measurement/estimation that fully accounts for the broader diversity in conditions and resources at the entity level.

Emissions Inventory Verification/Auditing

Verification of GHG Emissions Reductions for The City of Edmonton Landfill Gas Project (2006). Duncan Rotherham has carried out the verification of emissions reductions (2006 vintage) created as a result of activities at the City of Edmonton's LFG capture and combustion to energy project (CH_4 abatement). The verification involved a document review phase, an onsite visit to the facility to review source data and

confirm calculations described in the Project Documentation and ensure that no emission sources have been omitted in the reporting (for emission reduction claims). Based on the findings ICF issued a letter of opinion on the validity of the credits/generation claimed.

Verification of GHG Emissions Reductions for The City of Edmonton Landfill Gas Project (2004-2005): Duncan Rotherham has carried out the verification of emissions reductions (2004, 2005 vintage) created as a result of activities at the City of Edmonton's LFG capture and combustion to energy project (CH_4 abatement). The verification involved a document review phase, an onsite visit to the facility to review source data and confirm calculations described in the Project Documentation and ensure that no emission sources have been omitted in the reporting (for emission reduction claims). Based on the findings ICF issued a letter of opinion on the validity of the credits/generation claimed.

Validation of a Landfill Gas Project protocol. Duncan Rotherham has carried out the validation of the Canadian Government's GHG Verification Centre's *Landfill Gas Capture and Combustion Quantification Protocol* (used by the Technology Early Action Measures (TEAM) program called the System of Monitoring and Reporting for Technologies (SMART)) vs. Standard "offsets" system eligibility criteria including; Quantifiable, Real, Surplus, Verifiable, Unique, and Ownership. Based on this analysis ICF issued an opinion on whether a LFG capture and combustion project implementing the *Landfill Gas Capture and Combustion Quantification Protocol* would meet the requirements for the issuance of an Auditor's Letter quantifying emissions reductions per Alberta's G3 Permit Requirement.

Verification of GHG Emissions Reductions associated with a transportation/energy efficiency project for CCX.: Duncan Rotherham carried out a verification of emissions reductions created as a result of the adoption of IdleAire's Advanced Travel Center Electrification (ATE) technology. The verification involved a document review phase, an onsite visit to the facility to review source data and confirm calculations described in the Project Documentation and ensure that no emission sources have been omitted in the reporting (for emission reduction claims). Based on the findings ICF issued a letter of opinion on the validity of the credits/generation claimed and suitable for the purposes of listing the resulting ERs on the CCX registry.

Verification of GHG Emissions Reductions associated with two EOR projects. Duncan Rotherham carried out a verification of emissions reductions created as a result of CO_2 sequestration activities associated with 2 enhanced oil recovery projects in Wyoming. The verification involved a document review phase, an onsite visit to the facility to review source data and confirm calculations described in the Project Documentation and ensure that no emission sources have been omitted in the reporting (for emission reduction claims). Based on the findings ICF issued a letter of opinion on the validity of the credits/generation claimed and suitable for the purposes of listing the resulting ERs on the ERT registry.

The project proponent prepared and provided a Project Document and a calculation of ERs achieved through the period covered under the verification (2006). ICF offered input to the development of this document and commented on the completeness.

Verification of GHG Emissions Reductions for an acid gas recovery project (2004-2006). Since 2004 Duncan Rotherham has carried out the verification of emissions reductions (2004, 2005 and 2006 vintage) created as a result of activities at the Taylor Gas Processing Limited Partnership's (Taylor) acid gas injection project at the Turin sour gas processing facility (CO_2 abatement). The verification involved a document review phase, an onsite visit to the facility to review source data and confirm calculations described in the Project Documentation and ensure that no emission sources have been omitted in the reporting (for emission reduction claims). Based on the findings ICF issued a letter of opinion on the validity of the credits/generation claimed.

Verification of Renewable Energy Credits ("Green Tags") for Epcor (2004-2006): At the request of EPCOR ICF completed an audit of the renewable energy generation claims with the objective of offering

shipments were received every few hours on specialized trucks to facilitate loading and unloading. The operations were based on the Japanese kanban system. Due to the success of these operations, the company exported the model to Thailand. In that project, auto parts came from local suppliers in Thailand as well as from suppliers in Europe via ocean shipping or air transportation for emergency shipments. Mr. Facanha was responsible for process optimization associated with air shipments.

Cross-border Rail Transportation, General Motors (1999-2000). At APL Logistics, Dr. Facanha improved processes associated with the transportation of auto parts from the Detroit area to Mexico via rail. Among the obstacles for the success of this program were long and unreliable transit times. This was especially true for northbound moves (containing empty returnable crates) due to the lower priority of these shipments. After working with the railways on strategies to improve transit times, customs processes were identified as a significant bottleneck. The process was then streamlined, including electronic documentation, and advance documentation forwarding.

Distribution Management in Brazil, General Motors (1998-1999). While at Emery Global Logistics, Dr. Facanha participated in the implementation of an "Aftermarket Parts Distribution" program for an automotive manufacturer in Sao Paulo, Brazil. This program consisted in the distribution of auto parts from 2 warehouses to over 400 automotive dealers across Brazil.

SELECTED PUBLICATIONS AND PRESENTATIONS

Facanha, Cristiano, and Horvath, Arpad. "Life-cycle Emissions Factors of Freight Transportation in the United States." *Environmental Science and Technology*. Accepted for publication, 2007.

Facanha, Cristiano, and Ang-Olson, Jeffrey. "Effectiveness of Freight Transport Operational Strategies in Southern California". Presented at the World Conference on Transportation Research, Berkeley, California, June 2007.

Facanha, Cristiano. "Life-cycle Air Emissions Inventory of Freight Transportation in the United States." *Ph.D. Dissertation*, University of California at Berkeley, 2006.

Facanha, Cristiano, and Horvath, Arpad. "Environmental Assessment of Freight Transportation in the U.S." *International Journal of Life-Cycle Assessment*, 11 (4) pp. 229-239, 2006. Also presented at the Transportation Research Board (TRB) Conference in 2006.

Facanha, Cristiano, and Horvath, Arpad. "Environmental Assessment of Logistics Outsourcing." *Journal of Management in Engineering*, January, 2005.

AWARDS

National Science Foundation Graduate Fellowship, 2003-2006

STINT Fellowship, 1996-1997 (Swedish Foundation for Cooperation in Research and Higher Education)

LANGUAGES

Fluent English, Portuguese, and Spanish

EMPLOYMENT HISTORY

ICF International: Senior Associate	2006-present
APL Logistics: Manager, Logistics Analysis	1999-2002
Emery Global Logistics: Logistics Analyst	1998-1999
Stora Purchasing and Transport: Research Analyst	1997

ICF INTERNATIONAL

JONATHAN COHEN

EDUCATION

Ph.D., Statistics, Imperial College, London, England, 1982
M.S., Statistics, University of Birmingham, England, 1979
B.A., Mathematics, University of Oxford, England, 1978

EXPERIENCE OVERVIEW

Dr. Jonathan P. Cohen, Project Manager at ICF International, manages a wide variety of projects requiring his skills in statistical theory and its applications to the statistical data analysis of environmental land, air, and water quality and emissions data. He uses these skills in the design and analysis of experiments and sample surveys, general linear models, database management, applied probability, and statistical simulation.

Dr. Cohen co-manages ICF International's contract to support the U.S. EPA Office of Air Quality Planning and Standards. Under that contract, and previous support contracts, Dr. Cohen has managed a series of work assignments related to the analysis of ambient air quality monitoring data, including: the development of ozone and particulate matter data marts; analyses of trends and seasonal patterns in ambient concentrations of hazardous air pollutants (air toxics), used for U.S. EPA's National Air Quality and Emissions Trends Report, 1998, 1999 and 2000; analyses of enhanced ozone monitoring data; review and analysis of ozone and particulate matter design values and attainment tests; comparison of PM10 and PM2.5 ambient concentration data; analyses of alternate PM NAAQS; analyses of diurnal carbon monoxide concentration patterns and alternate NAAQS; review of public comments on the ozone and particulate matter standards; preparation of Guideline documents; and the development of model performance evaluation methods.

SELECT PROJECT EXPERIENCE

Economic Analysis of the SunWise Program, 2003-present. For the U.S. EPA, Dr. Cohen provided expert input on the methodology to perform an economic analysis of the effectiveness of the SunWise Program, a national health and environmental education program designed to teach children in elementary and middle schools how to protect themselves from overexposure to the sun. In particular, Dr. Cohen provided guidance on the statistical analysis of student pre-test and post-test surveys.

Commuter Choice Leadership Initiative, U.S. EPA's Commuter Choice Leadership Initiative. Dr. Cohen developed guidance on sample surveys for use by employers in the voluntary program who needed to survey their workforce on high occupancy vehicle usage. The guidance document included minimum sample size requirements for the survey to meet the program's precision goals.

Bay Area Spare the Air Campaign, Bay Area Air Quality Management District. Dr. Cohen helped design and analyze a series of telephone surveys of San Francisco Bay Area residents to evaluate their awareness and response to the Spare the Air campaign. On summer Spare the Air Days and selected control days, the respondents were asked about their awareness of the Spare the Air Day and whether they had responded by reducing driving, lawn mowing, or their use of aerosol products. On winter days, the respondents were asked about their awareness of the winter season campaign and about their fireplace type and usage.

Refinery Leaks, U.S. EPA. To provide support to the Petroleum Refining Subcommittee of the Common Sense Initiative Council, Dr. Cohen managed the survey design and statistical analysis tasks for a survey of leaking components at petroleum refineries. Dr. Cohen managed the random selection of 25 refineries for the survey. Dr. Cohen then managed the data compilation and data analysis of the collected public

data on leak frequencies by component type, with the goal of determining which types of component or processes are associated with the most frequent leaks.

Emissions Inventory, Association of Governments. Dr. Cohen assisted in the design of a bottom-up emissions inventory sample survey of several major non-road source groups including commercial and residential lawnmowers. An initial telephone survey of sources from selected categories was designed and analyzed and the results of that survey were used to develop a much larger mail survey.

Methane Emissions from Natural Gas, U.S. EPA Natural Gas Star Research Program. Dr. Cohen reviewed the statistical sample survey methodologies used by a Gas Research Institute contractor to develop a national inventory of methane emissions from natural gas facilities. This review was focused on alternative approaches for weighting site equipment activity factors to give regional activity factors, including the comparison of ratio, regression, and mean ratio estimates and review of alternative methodologies for uncertainty estimation.

SELECTED PUBLICATIONS AND PRESENTATIONS

"Quality Assurance / Quality Control and Uncertainty Management Plan for the U.S. Greenhouse Gas Inventory: Procedures Manual for Quality Assurance / Quality Control and Uncertainty Analysis" (with others). EPA 430-R-02-007B (June, 2002).

"Speed Correction Factor Improvement: Vehicle Emission Testing Of 30 Passenger Cars And Light-Duty Trucks." (with Clean Air Vehicle Technology Center). ICF 02-069. Prepared for California Department of Transportation (July, 2002).

"Estimating Statistical Uncertainties in the Greenhouse Gas Emissions Measurement and Reporting Protocols for the UK Trading Scheme" (with others). Prepared for United Kingdom Department of Food and Rural Affairs. (February, 2002).

A Statistical Analyses of Vehicle Test Data from a Crossover Study.@ Prepared for EPA Office of Transportation and Air Quality (2001).

EMPLOYMENT HISTORY

ICF International: Project Manager	1997-present
Systems Applications International: Principal Statistician, Group Manager, Senior Statistician II	1989-present
University of Kentucky, Dept. of Statistics: Assistant Professor	1984-1989
University of Minnesota, Dept. of Theoretical Statistics: Visiting Assistant Professor	1982-1984
Polytechnic of Central London: Lecturer in Statistics	1982
Abbey Business School, London: Lecturer in Business Statistics	1982

ROBERT LANZA **ICF INTERNATIONAL**

EDUCATION

M.Eng., Chemical Engineering, Cornell University, Ithaca, New York, 1982
B.Sc., Chemical Engineering, Cornell University, Ithaca, New York, 1980.

EXPERIENCE OVERVIEW

Mr. Robert Lanza, P.E. is a Principal Chemical Engineer with more than 25 years of experience in conducting environmental assessments of private sector and government facilities; managing preparation of Environmental Impact Statements and Assessments; preparing environmental permit applications; providing regulatory development and environmental program management support to Federal agencies, and providing assistance in preparing technical analyses and carbon storage and emission calculations for the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* for the U.S. EPA. Mr. Lanza holds M.Eng. and B.Sc. degrees in Chemical Engineering from Cornell University, and is a Licensed Professional Engineer in Maryland. Mr. Lanza is Lead Author of the Intergovernmental Panel on Climate Change (IPCC) 2006 Greenhouse Gas Inventory Guidelines (2006 GL) for Petrochemical and Carbon Black Production and a Contributing Author to the 2006 GL for Iron and Steel and Metallurgical Coke Production. Mr. Lanza is also a principal author of Environmental Impact Statements for the proposed Yucca Mountain Transportation Rail Alignment and proposed new Uranium Enrichment Facility for the U.S. Department of Energy (DOE) and was Quality Assurance Manager for the Environmental Impact Statement for the expansion of the Strategic Petroleum Reserve. Mr. Lanza is also providing engineering support to the U.S. EPA Sector Strategies Program concerning the beneficial use of alternative fuels and raw materials in cement kilns and other industry sectors, and is also providing technical support to U.S. EPA for assessment of ozone-depleting substances destruction and for lifecycle analysis of packaging materials.

SELECT PROJECT EXPERIENCE

Lifecycle Analysis and Greenhouse Gas Emission Factor Development

Solid Waste Management and Greenhouse Gases, U.S. EPA (2007-Present). Mr. Lanza is providing engineering support to the U.S. EPA in Climate and Waste program in developing Greenhouse Gas emission factors for packaging materials. The energy and associated GHG emissions implications of waste management practices for specific products accrue throughout its lifecycle and thus product-specific energy and emission factors typically require a lifecycle analysis to quantify the benefits. Mr. Lanza is providing engineering support for generating new and revised emission factors for EPA's online tools including WARM and ReCon using lifecycle data and methodology. The revised emission factors for existing materials include the three currently modeled plastics (HDPE, LDPE, PET) as well as aluminum and paper. The new emission factors for additional materials include five new plastics (PP, LLDPE, PVC, PS, and EPS). Mr. Lanza's activities include reviewing and assessing lifecycle data provided by stakeholders, reviewing emission factor estimates based on these data, and preparing client communications.

GreenBlue Institute and Sustainable Packaging Coalition (2007-Present). Mr. Lanza is providing engineering support to GreenBlue's efforts to obtain industry-specific lifecycle data on 17 material types including seven plastics, various paper types, glass, aluminum, and steel in order to update and expand the MERGE tool (Managing Environmental Resources, Guidance and Evaluation) for analysis of the greenhouse gas, energy, and resource intensity impacts of various types of packaging materials. The MERGE tool was originally developed by Environmental Defense and is now part of the Sustainable Packaging Coalition. The GreenBlue Template, which allows industry representatives to detail the various unit processes (e.g. crude oil extraction, natural gas combustion, water inflow, etc.) such that the

energy and associated GHG implications can be assessed and characterized. Mr. Lanza is providing engineering support towards the effort to match the industry data provided in the GreenBlue Template with existing lifecycle data in existing databases including the US Lifecycle Inventory and Europe's EcoInvent, and also in reviewing emission factor calculations and preparing client communications. The goal of the project is to provide transparent and updated unit process information on the various material types such that a supply-chain lifecycle assessment will be readily available to retailers and the public.

National Greenhouse Gas Inventory Program

Intergovernmental Program on Climate Change 2006 National Greenhouse Gas Inventories Guidelines, U.S. Environmental Protection Agency (2004-2006). Mr. Lanza is a Principal Author the 2006 IPCC National Greenhouse Gas Inventory Guidelines (2006 GL) methodology for petrochemical and carbon black production, and is a Contributing Author of the 2006 GL of the methodology for iron and steel and metallurgical coke production. The 2006 GL will be used by national governments in preparing their national greenhouse gas inventories. The petrochemical and carbon black industry section of the 2006 Guidelines is a new section that was not included in the 1996 Guidelines. Mr. Lanza and two coauthors developed the outline for the draft section, identified the specific petrochemical industries to be included, and collected data from published data sources and from industry sources and developed methodologies to estimate greenhouse gas emissions from these processes. Petrochemical processes included in the petrochemical industry section of the 2006 GL include methanol, ethylene, ethylene dichloride, ethylene oxide, acrylonitrile, and carbon black production. As a Contributing Author of the 2006 GL methodology for iron and steel and metallurgical coke production, Mr. Lanza worked with the Lead Author to develop process flow diagrams for metallurgical coke production, iron sinter production, iron making and steel making processes, identify data sources for process data and greenhouse gas emission factors, and develop greenhouse gas emissions estimation methodologies, Mr. Lanza also provided review comments for other sections of the 2006 GL, including cement production, petrochemical product use, and carbon transport, injection, and storage (sequestration.) As part of this work Mr. Lanza attended a series of four IPCC Working Group Conferences in Bethesda Maryland, July 2004; Manila Philippines, January 2005; Moscow, Russian Federation, July 2005; and Sydney Australia, December 2005.

National Greenhouse Gas Inventory Preparation, Industrial Process Sources, U.S. EPA (2001-Present). Mr. Lanza is providing engineering support to the Greenhouse Gas Inventory Program in the U.S. EPA Office of Atmospheric Programs and is assisting the EPA in developing and revising methodologies for calculating carbon emissions and sinks for industrial process sources for incorporation into the National Greenhouse Gas Inventory. Mr. Lanza developed new and revised methodologies for lead production, zinc production, iron and steel production, titanium oxide production, primary aluminum production, and other industrial processes that use coal coke or petroleum coke as raw materials. He also assisted in developing methodologies to estimate carbon dioxide emissions from industrial utilization of carbon dioxide and developed emission factors for non-fuel uses of fossil fuels and petrochemical feedstocks. Mr. Lanza is coordinating interagency communications between the DOE Energy Information Administration and the Greenhouse Gas Inventory Program to research methods to supplement existing data collection tools and potentially develop additional data collection tools for non-fuel use data, and is also developing methodologies to modify existing U.S. inventory methodologies in response to publication of the revised IPCC Inventory guidelines in 2006.

National Greenhouse Gas Inventory Preparation, Carbon Transport, Injection, and Storage, U.S. EPA (2002-2007). Mr. Lanza provided technical support to U.S. EPA in developing a country-specific inventory methodology for carbon capture, transport, injection, and storage operations, including capture of carbon dioxide from natural gas processing plants and natural carbon dioxide reservoir and pipeline transport and utilization of carbon dioxide in Enhanced Oil Recovery operations. Mr. Lanza and other ICF staff conducted a preliminary analysis for the EPA of approaches to incorporating carbon sequestration into the U.S. inventory, including identifying potential data sources. Mr. Lanza and other ICF staff also provided technical comments on the draft 2006 IPCC Inventory Guidelines chapters for Carbon Capture

and Storage and Fugitive Emissions from Oil and Natural Gas Systems. Mr. Lanza assisted in identifying potential greenhouse gas emissions sources and sinks associated with petroleum and natural gas production and carbon capture and storage operations, identified potential areas of overlap between the Carbon Capture and Storage Chapter and Fugitive Emissions from Oil and Natural Gas Systems Chapter of the 2006 Guidelines and provided technical review of the draft Chapters. ICF was then tasked by the U.S. EPA to implement the 2006 IPCC Inventory Guidelines for Carbon Transport, Injection, and Storage for the U.S. Inventory. Mr. Lanza managed development of a draft methodology for carbon capture from natural carbon dioxide reservoirs, natural gas treatment plants, and industrial sources, collection and analysis of data for carbon dioxide transport and utilization in Enhanced Oil Recovery Operations, and preparation of inventory calculations and quality assurance/quality control reporting forms for the U.S. Inventory. Mr. Lanza is also assisting EPA in conducting an assessment of minimum data requirements and potential sources of data to support carbon sequestration calculations for Enhanced Oil Recovery Operations for the U.S. Inventory, including assessment of existing EPA and State regulatory permitting requirements for injection wells. The 2006 IPCC Guidelines indicate that unless specific data requirements are met, all carbon dioxide utilized in Enhanced Oil Recovery operations is to be assumed to be emitted to the atmosphere, and none is to be assumed stored.

National Greenhouse Gas Inventory Non-energy Uses of Fuel Feedstocks, U.S. EPA (2001-Present). Mr. Lanza assisted in developing carbon storage and emissions calculations for non-energy uses of fossil fuel feedstocks, including petrochemical feedstock naphthas, liquefied petroleum gases, natural gas, industrial coking coal, and petroleum coke. He also assisted in the development of carbon storage and emissions calculation methodologies for industrial process sources including iron and steel, aluminum, ferroalloys, and titanium dioxide production, and contributed to sections of the report entitled *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2004.*

Non-energy Uses of Fossil Fuels Workshops, U.S. EPA (2001-2006). Mr. Lanza assisted in developing and presenting the paper *Non-Energy Uses of Fossil Fuels: US GHG Inventory Methods and Results* at the Third NEU-CO_2 Workshop on Non-Energy Use and CO_2 Emissions, hosted by the International Energy Agency in Paris, France, November 2001. The paper described the methodology and results of calculations of carbon emissions and storage factors for non-energy uses of fossil fuels for the 2000 U.S. GHG Inventory, including petrochemical feedstock and industrial process non-fuel uses. Mr. Lanza also prepared an evaluation of the NEAT Simplified Approach Model developed by the University of Utrecht for estimating non-energy uses of fossil fuels and a comparison of the NEAT Simplified Approach Model methodology and boundary conditions to the methodology and boundary conditions used to estimate non-energy uses of fossil fuels for the U.S. Greenhouse Gas Inventory. The comparative analysis was presented at the February 2006 NEU-CO_2 Workshop in Utrecht, hosted by the University of Utrecht.

U.S. EPA Sector Strategies Industrial Sector Greenhouse Gas Emission Estimates (2007). Mr. Lanza provided engineering support to EPA in preparing greenhouse gas (GHG) emission estimates for fourteen U.S. industrial sectors for EPA's sector strategies division, including Alumina and Aluminum, Cement, Chemicals, Food and Beverages, Forest Products, Iron and Steel, Lime, Oil and Gas, and Mining, among others. The GHG emission estimates accounted for energy consumption from both direct (on-site fossil fuel combustion) and indirect (purchased electricity) sources as well as non-combustion (e.g., industrial process, wastewater) sources. For this work, ICF mapped facility-level energy consumption data to North American Electricity Reliability Corporation (NERC) regions to develop highly-specific electricity-related emission estimates using eGRID emission factors. ICF has also prepared GHG emission estimates for the Shipbuilding, Paints and Coatings, and Colleges and Universities sectors, and has recently developed an Excel-based GHG accounting tool for the Shipbuilding sector.

Economic Sector Greenhouse Gas Threshold Analysis (2007). Mr. Lanza provided engineering support to U.S. EPA in preparing estimates of the number of establishments within U.S. agricultural, commercial, industrial, and residential sectors that emitted greenhouse gases (GHG) in amounts exceeding specified thresholds (e.g., 1,000 tons CO_2E per year). The analysis included estimates of establishments

exceeding thresholds on a by-gas (e.g., CO_2, CH_4) and equivalent basis for actual and potential emissions, and was performed on a quick-response task basis. Mr. Lanza coordinated the identification and evaluation of data sources, research on activity data statistics, and development and application of number of establishment and emissions estimation methodologies and emission factors for each category of GHG emission. Through this work, ICF demonstrated the suite of resources we are able to bring to a quick-response task, involving key experts to inform and QA/QC the analysis, a diverse set of support staff to perform research and calculations, and a structured management system that consistently met daily deadlines. By distributing the work among staff, ICF was able to prepare high-quality estimates in a short period—performing over 400 hours of work in two weeks while keeping per-hour costs low.

Greenhouse Gas and Regulated Pollutant Air Emissions Inventory Audits

Greenhouse Gas and Regulated Pollutant Air Emissions Inventory Audits, Petrobras (Brazil) (2007-Present). Mr. Lanza is one of several "lead auditors" conducting audits greenhouse gas and regulated air emissions inventories for Petrobras business units. Mr. Lanza led one business unit audit and participated in two others in 2007, with additional audits anticipated in 2008. The core objective of this project is to verify the atmospheric emission inventories for the years 2005, 2006 and 2007, including Greenhouse Gases (GHGs) and Regulated Pollutants, and to identify lacunae and improvements in the consolidation of inventory data generated by the Atmospheric Emission Management System ("SIGEA"), in addition to building capacity for internal verification of inventories by the Company itself. The ultimate intention is to achieve progressive reliability of information on atmospheric emissions, both for internal management by Petrobras and for purposes of voluntary reporting by the Company to stakeholders. The audit and verification process was based on the Instructions Protocol developed by ICF for application to the critical analysis and identification of improvements in the quality of inventories generated by the SIGEA.

National Environmental Policy Act Program

Environmental Impact Statement for Proposed Nevada Rail Line (2004-Present). Mr. Lanza is task manager for preparation of an Environmental Impact Statement for a proposed rail line to transport spent nuclear reactor fuel and naval reactor fuel to the proposed Yucca Mountain Repository site in Nevada. Mr. Lanza is responsible for preparing the Occupational and Public Health and Safety section of the EIS. This section assesses potential non-radiological and radiological occupational and public health impacts from construction and operation of the proposed rail line and ancillary facilities in Nevada (the Proposed Action), and also potential impacts from construction and operation of heavy-haul truck routes (the No Action Alternative) for transportation of spent fuel to the proposed Repository.

Environmental Impact Statement for Proposed Expansion of U.S. Department of Energy Strategic Petroleum Reserve (2005-2006). Mr. Lanza was Quality Assurance Manager for preparation of the Environmental Impact Statement for the proposed expansion of the U.S. DOE Strategic Petroleum Reserve. The proposed expansion would expand the storage capacity of the SPR to 1 billion barrels of crude oil, and involve the construction of one or two new SPR sites and the expansion of two or three existing SPR sites. Mr. Lanza was responsible for reviewing the text, tables, references, and calculations for the draft EIS for consistency with original data sources, technical accuracy, and resolution of cross-cutting issues.

Environmental Impact Statement for Proposed Uranium Enrichment Facility (2004-2006). Mr. Lanza participated in preparing an Environmental Impact Statement (EIS) for a proposed new uranium enrichment facility for the USEC. For this project Mr. Lanza prepared chapters of the EIS related to waste generation and waste management, including generation and management of depleted uranium, other radioactive wastes, hazardous wastes and solid wastes This task included evaluating the types and quantities of waste anticipated to be generated by the Proposed Action and Alternatives, the proposed

management and disposal programs applicable to such wastes, and the potential environmental consequences of waste generation, management, and disposal.

Environmental Impact Statement for Proposed New Rail Line, Surface Transportation Board (2002-2003). Mr. Lanza participated in preparation of an Environmental Impact Statement (EIS) for a new rail line for the Surface Transportation Board. For this project Mr. Lanza provided quality assurance reviews for chapters of the EIS and for public comment excerpts, summaries, and draft comment responses for public comment response documents for the EIS. Mr. Lanza reviewed the public comment excerpts and summaries and draft agency responses with respect to consistency of the excerpts and summaries and responsiveness of the draft comment responses. Impact categories for which Mr. Lanza provided quality assurance review included NEPA process, purpose and need for the proposed action, proposed action and alternatives, railroad operation safety, grade crossings, hazardous materials transportation, environmental justice, noise, air quality, water resources, land use, and socioeconomics.

Environmental Assessment, Drug Enforcement Administration Clandestine Drug Laboratory Cleanup Program, (2002-2003). Mr. Lanza managed preparation of an Environmental Assessment for the DEA Clandestine Laboratory Cleanup Program. The program provides for removal and management of hazardous wastes that may be discovered at clandestine drug laboratories seized in the conduct of law enforcement activities. The Environmental Assessment included the Current Program Alternative, under which DEA contractors conduct the removal actions, a Proposed Alternative under which law enforcement personnel would conduct the removal actions without DEA contractor involvement, and the No Action Alternative, under which the Current Program would not be funded and no hazardous waste management activities would be conducted. Under the No Action Alternative, any hazardous wastes encountered at clandestine drug laboratories are assumed to be left in place after law enforcement actions are completed. Environmental consequence analyses conducted for the Environmental Assessment included assessment of occupational health and safety impacts and public exposure impacts associated with hazardous waste removal, transportation, and temporary storage under normal operations and potential accidental release scenarios. Environmental justice impacts and impacts to children of the Alternatives were also evaluated.

Environmental Assessment, Department of Justice Office of Community-Oriented Policing Services Methamphetamine Initiative (2002-2003). Mr. Lanza managed preparation of an Environmental Assessment for the DOJ COPS Office Methamphetamine Initiative. The program provides funding to state and local law enforcement agencies to supplement existing state and local funding for methamphetamine programs. The grant funding may be applied to fund law enforcement, technical, and administrative personnel to conduct and support identification and seizure of clandestine methamphetamine laboratories, and may be applied to fund purchase of equipment and administration of law enforcement and health and safety training. Grant-funded personnel and grant-funded equipment may be involved in removal and management of hazardous wastes that may be discovered at clandestine drug laboratories seized in the conduct of law enforcement activities. The Environmental Assessment included the Current Program Alternative, under which grants are provided to law enforcement agencies, and the No Action Alternative, under which the Current Program would not be funded and no grant-funded personnel, equipment, or training would be provided. Under the No Action Alternative, any hazardous wastes encountered at clandestine drug laboratories are assumed to be managed by DEA or other non-grant funded agencies. Environmental consequence analyses conducted for the Environmental Assessment included assessment of occupational health and safety impacts and public exposure impacts associated with hazardous waste removal, transportation, temporary storage, and disposal under normal operations and potential accidental release scenarios. Regulatory programs related to grant-funded hazardous waste management activities were summarized in the Environmental Assessment. The environmental consequences of elimination of grant funding and related reduced availability of personnel and law enforcement and health and safety, equipment and training under the No

Action Alternative were also assessed, and environmental justice impacts and impacts to children were also evaluated for both the Proposed Action and No Action Alternatives.

Environmental Assessment, Federal Motor Carrier Safety Administration Proposed Hours of Service Regulation (2002). Mr. Lanza assisted in preparing an environmental impact statement for the proposed FMCSA Hours of Service (HOS) regulation. The existing HOS regulations address the number of hours that a commercial motor vehicle (CMV) operator may drive, and the number of hours a CMV driver may be on duty, before rest is required. Proposed changes to the HOS regulations (the Proposed Action) and Alternatives would change the number of hours and potentially affect the operations of CMV drivers and rail freight carriers. The purpose of the Proposed Action is to improve CMV safety by revising the FMCSA HOS regulations to require motor carriers to provide CMV drivers with expanded periods of rest, which in turn will provide drivers with better opportunities to obtain sleep. The Environmental Assessment addresses the affects of these potential changes on the number of anticipated fatigue-related crashes and the number of vehicle miles traveled, the number of vehicle hours idling, and potential mode shift of freight transportation from truck to rail, and the effects of such potential changes on air emissions and air quality, land use, noise, safety, socioeconomics, and energy consumption. The Environmental Assessment was prepared on conjunction with a Regulatory Impact Assessment (RIA) for the proposed HOS regulations.

NEPA Program Support for Office of NEPA Policy and Assistance, U.S. Department of Energy (1989-1999). Mr. Lanza provided support to the DOE Office of NEPA Policy and Assistance through a contract with Oak Ridge National Laboratory. Mr. Lanza reviewed and prepared technical comments for Environmental Impact Statements and Environmental Assessments for proposed radioactive and hazardous mixed waste treatment facilities, and evaluated environmental impact analyses prepared for the proposed facilities, including human health risk, occupational exposure, visibility, air quality, and ecology impacts. Mr. Lanza also prepared technical comments on an Environmental Impact Statement for a proposed high-level radioactive waste treatment facility, which included an evaluation of impacts of transportation of high-level waste between and within DOE sites. Mr. Lanza performed technical and regulatory reviews of more than 25 NEPA documents, including Environmental Impact Statements and Environmental Assessments, over the 10-year duration of the project. Mr. Lanza also attended meetings of the Nuclear Waste Technical Review Board and the Advisory Committee on Nuclear Waste in order to develop summaries of technical and policy issues related to the NEPA review process for the proposed Yucca Mountain high-level radioactive waste geologic repository, including site characterization, construction, waste management, high-level waste transportation and radiation safety issues.

Review of Environmental Assessment for Proposed Radioactive Mixed Waste Vitrification Facility, U.S. Department of Energy (1998-1999). Mr. Lanza assisted the DOE Office of NEPA Policy and Assistance in providing technical review of the draft Environmental Assessment for the proposed VORTEC Vitrification facility at the Paducah Site. The VORTEC technology is an experimental technology to vitrify mixed radioactive and PCB-waste contaminated soils and other wastes to produce a glass matrix. Mr. Lanza reviewed the draft and revised draft Environmental Assessments and prepared comments on technical and regulatory issues, including anticipated environmental permitting requirements for the proposed facility under Resource Conservation and Recovery Act (RCRA), Toxic Substances Control Act (TSCA), and Clean Air Act (CAAA) regulations. Regulatory issues addressed included the recently promulgated PCB Megarule, proposed CAAA hazardous waste combustion Maximum Achievable Control Technology (MACT) standards, and RCRA Land Disposal Restrictions. Technical issues addressed included the methodology for estimating air emissions and off site impacts from routine operation and potential accidental releases from the proposed facility, occupational exposure issues, and the potential for impacts to other environmental media.

Review of NEPA Documentation for Proposed Hazardous Waste Incinerator, U.S. Department of Energy (1989-1993). Mr. Lanza provided engineering support to the DOE Office of NEPA Policy and Assistance in conducting reviews of Environmental Assessments and associated NEPA documentation for a

proposed hazardous waste incinerator at the Savannah River Site. A review of the draft Environmental Assessment conducted by Mr. Lanza in 1989 identified technical and regulatory deficiencies, which were transmitted to DOE in a series of meetings with DOE headquarters and facility staff. In 1992, Mr. Lanza provided support to DOE in preparing responses to public comments on the Environmental Assessment and provided additional support to DOE in preparing responses to internal DOE comments on the revised Environmental Assessment and associated NEPA documentation. Mr. Lanza managed a staff of three engineers and scientists on portions of this project. The schedule for the construction and operation of this new incineration facility was mandated by an interagency agreement, and therefore the EA review and public comment response tasks were completed on a short schedule.

Review of Environmental Impact Statement for Advanced Mixed Waste Treatment Facility, U.S. Department of Energy (1998-1999). Mr. Lanza provided support to the DOE Office of NEPA Policy and Assistance in providing technical comments on the Environmental Impact Statement for the proposed Advanced Mixed Waste Treatment Project (AMWTP) at Idaho National Environmental and Engineering Laboratory (INEEL). INEEL proposed to construct an integrated mixed waste management facility, including macroencapsulation, supercompaction, incineration, vitrification, and miscellaneous glovebox treatment technologies to treat mixed radioactive/ hazardous waste and PCB-contaminated radioactive waste. Mr. Lanza reviewed the initial draft and revised draft Environmental Impact Statement and provided comments to the Office of NEPA Policy and Assistance and to INEEL in a series of meetings. Mr. Lanza provided comments on many aspects of the EIS, including Purpose and Need for Agency Action, Alternatives Analysis, Environmental Consequences, and Mitigation. Specific issues addressed included the selection of alternative treatment technologies for evaluation in the EIS, methodology for estimating impacts to aesthetic and scenic resources, air quality, and ecology, occupational health and safety analysis, facility accident analysis, and cumulative impacts analysis. DOE required preparation of written comments on the Revised Draft Environmental Impact Statement on an expedited schedule to meet schedule requirements for a series of meetings with DOE and INEEL technical staff and schedule requirements for release of the Final Environmental Impact Statement for public comment.

Review of Hanford Comprehensive Land-Use Plan Environmental Impact Statement, U.S. Department of Energy (1999). Mr. Lanza assisted the DOE Office of Planning and Budget in providing technical and regulatory comments on the Environmental Impact Statement for the Comprehensive Land Use Plan (CLUP) for the DOE Hanford Site. Mr. Lanza reviewed the land use alternatives included in the Environmental Impact Statement with respect to consistency in terminology, and evaluated potential effects of each alternative on the management of existing natural and cultural resource areas within the Hanford Site. Mr. Lanza also reviewed the draft Record of Decision for the Environmental Impact Statement with respect to technical and regulatory issues and consistency of terminology and definitions with the Environmental Impact Statement. The review indicated that small differences in the terminology used to describe land use definitions for the alternatives could potentially result in differences in how natural and cultural resource areas would be managed under the CLUP. Mr. Lanza also evaluated technical and regulatory issues related to transfer of management responsibility for the Wahluke (North) Slope of the Hanford Site from the Washington Department of Ecology to the U.S. Fish and Wildlife Service (USFWS) which was proposed at about the same time as the draft Environmental Impact Statement was being finalized. At the time, the two sections of the Wahluke Slope were managed by different agencies under permit by DOE. The technical and regulatory review concluded that NEPA review was not required for DOE to issue a permit to the U.S. Fish and Wildlife Service to manage the entire Wahluke Slope if the uses of the land permitted by DOE would remain unchanged under the new permit The Department subsequently issued a permit to the USFWS for management of the entire Wahluke Slope.

Environmental Impact Statement, U.S. Food and Drug Administration Consolidation Facility, Montgomery County Campus (1994-1995). Mr. Lanza assisted in preparing the draft Environmental Impact Statement for the U.S. Food and Drug Administration Consolidation Facility, Montgomery County Campus. Mr.

Lanza assisted in preparing the sections of the draft Environmental Impact Statement on medical waste incineration and radioactive waste management, including characterization of waste types and estimation of air emissions, and assessment of potential risks from incineration of medical wastes and assessment of alternatives to medical waste incineration. Mr. Lanza also participated in public meetings and workshops concerning the proposed project in Montgomery County, Maryland.

Licensing and Rulemaking Support for U.S. Nuclear Regulatory Commission

Generic Environmental Impact Statement, Nuclear Regulatory Commission Proposed Solid Materials Rule (2003-2005). Mr. Lanza was task manager for preparation of a draft Generic Environmental Impact Statement (GEIS) for the proposed issuance of a Nuclear Regulatory Commission (NRC) Rule for release of solid materials from licensed facilities. The action being considered in the GEIS is an amendment to existing NRC regulations to include criteria for controlling the disposition of solid materials that originate in restricted or impacted areas of NRC-licensed facilities, and that have no, or very small amounts of, radioactivity resulting from licensed operations (collectively referred to as Asolid materials@). Mr. Lanza managed preparation of sections of the draft GEIS related to Affected Environment and Environmental Consequences of the Proposed Action. These sections included a description of the affected environment and environmental consequences related to potential end uses of recycled solid materials, including potential radiation dose to workers and the public related to the generation on site and transportation off site of solid materials, the recycling of solid materials into end use products, and utilization and disposal of the end use products. The affected environment and environmental consequences associated with the direct disposal of solid materials in either EPA- or state-regulated landfills or licensed low level radioactive waste disposal facilities was also evaluated in the draft GEIS. Environmental consequences evaluated in the GEIS also include potential transportation incidents, non-radiological releases to air and water, and potential impacts to the disposal capacity of existing solid waste landfills and existing low level radioactive waste disposal facilities.

Regulatory Analysis of Generic Safety Issue GS-189 for Nuclear Regulatory Commission (2004-2005). Mr. Lanza was task manager for preparation of a Draft Regulatory Analysis [Cost Benefit Analysis] of an NRC proposed action to address Generic Safety Issue 189: Susceptibility of Ice Condenser and Mark III Reactor Containments to Early Failure from Hydrogen Combustion during a Severe Accident. The Regulatory Analysis addressed the costs and benefits of reactor operators providing backup electric power generation capacity to power the hydrogen igniters during station blackout (SBO) conditions. Alternatives for which the costs and benefits are evaluated include the No Action, and NRC rule making or other action to require installation of stationary or portable electric power generators.

Environmental Impact Statement for Proposed Private Fuel Storage Facility (2002-2003). Mr. Lanza assisted the Nuclear Regulatory Commission in preparation of the Environmental Impact Statement for the proposed Private Fuel Storage (PFS) facility in Utah. The Proposed PFS facility would provide above ground storage for spent nuclear fuel. Mr. Lanza assisted in developing responses to public comments on the draft EIS.

Engineering and Economic Analyses for Cement Manufacturing Sector

Analysis of Regulatory and Technical Issues for Utilization of Petroleum Coke in Cement Kilns, U.S. EPA (2003). Mr. Lanza managed preparation of a report to the EPA Office of Policy, Economics, and Innovation evaluating regulatory and technical issues related to utilization of petroleum coke as an alternate to burning coal in cement kilns. The task involved evaluating regulatory issues associated with fuel switching in cement kilns, including the potential that a cement kiln switching from coal to petroleum coke would require New Source Review (NSR) and/or Prevention of Significant Deterioration review under the Clean Air Act. The task also involved evaluating technical issues concerning the comparative performance of petroleum coke vs. coal with respect to cement kiln operation and air emissions. Mr. Lanza researched the capability of cement kilns to absorb sulfur from the petroleum coke and coal fuels

(and also from the raw materials), and the comparative cost of operating cement kilns using coal vs. petroleum coke. Mr. Lanza also reviewed air emissions operating permit and permit conditions for several cement kilns permitted to burn both coal and petroleum coke, and also researched trends in petroleum coke in the cement industry.

Analysis of Technical and Regulatory Issues, Portland Cement Association Resource Conservation Challenge – Cement Kiln Dust (2004). Mr. Lanza managed preparation of a technical and regulatory analysis of the risks associated with disposal of cement kiln dust (CKD) and a review of current state regulations and site-specific permit conditions applicable to CKD disposal. This project was conducted for EPA in response to issues raised in the Resource Conservation Challenge prepared by the Portland Cement Association. Project tasks included preparing a summary of risks identified for CKD and other ABevill@ mineral processing wastes in EPA Regulatory Determinations, preparing a summary of state regulations applicable to CKD disposal and site-specific permit conditions applicable to CKD disposal sites, and preparing an assessment of the CKD management program proposed by the Portland Cement Association in the Research Conservation Challenge. Mr. Lanza and staff collected and reviewed state regulations and permits and interviewed state agency permit writers and inspectors to assess how state regulators and permit requirements for CKD disposal are being implemented in practice, and compared those results to the CKD management program proposed by the Portland Cement Association.

Analysis of Utilization Trends and Regulatory Requirements for Beneficial Use of Industrial By-Products in Cement Kilns (2005). Mr. Lanza managed preparation of an analysis of utilization trends and regulatory requirements for utilization of industrial by-products in cement kilns. Task 1 of the project was to identify the quantities of certain industrial by-products utilized by cement kilns in the production of cement clinker (i.e., used as either raw materials or fuels in the cement kiln) and utilization trends for the industrial by-products including: Steel slag; Foundry sand; Fly ash (from coal-fired power plants); Scrap tires (tire-derived fuel); Scrap paper/wood; Waste/off-specification paint; Used oil; Refinery catalysts/slurry oil; Spent aluminum potliners; and Animal meal (rendering by-products). For Task 2 of the project the objective was to identify differences in state agency permitting requirements for the transfer and utilization of by-products as fuels or raw materials in cement kilns. For this task state agency representatives were contacted and research conducted to assess which industrial by-products are being utilized in cement kilns in which states and to assess how state regulations are affecting the beneficial use of these materials.

Economic Analysis of Beneficial Use of Industrial Materials in Cement Kilns, U.S. EPA (2006-Present). Mr. Lanza is providing support to U.S. EPA in developing reports analyzing regulatory, policy, and performance issues related to assessment of economic, technical, and regulatory barriers to the use of alternative fuels and raw materials in cement production. Mr. Lanza is working with EPA and the Portland Cement Association and their member companies to collect data concerning the supply and use of raw materials (e.g., foundry sand, steel slag) and waste products (e.g., cement kiln dust, clarified slurry oil solids) by cement plants. Issues to be addressed in the study include regional variability in the supply and use of alternative fuels and raw materials; regional variability in lifecycle costs of reuse or disposal of these materials; regional differences and/or similarities in regulations or permits applicable to the use of these materials; and actual reductions in cost or criteria pollutant air emissions (SO_x, NO_x, particulate matter) from use of such materials in cement kilns. Information will also be obtained from material suppliers (e.g., foundries, steel mills) and state and federal regulatory agencies (e.g., permitting agencies) under this project.

White Paper on Cross-Sector Beneficial Use of Industrial Materials (2006-Present). Mr. Lanza is participating in developing a white paper for U.S. EPA's Sector Strategies Division on cross-sector beneficial reuse of industrial materials in the Gulf Coast States. Analyzing data, ICF determined the top industries in the Gulf Coast States and how each coincides with EPA's industry sectors of interest. Mr. Lanza is principal author of the section of the white paper on cement production, and he is also providing research and analysis for industrial sectors including metal casting (foundries), electric power generation,

forest products, oil and gas production, and construction and demolition. For this project ICF analyzed byproducts from the industries, along with reuses of those byproducts within and across industry sectors. ICF is analyzing the drivers and barriers for beneficial reuse of these byproducts across industry sectors, which include construction and demolition, iron and steel mills, forest products, foundries, cement industry, fossil fuel electric power generation, oil and gas extraction, petroleum refining, and the chemicals industry. The white paper will inform EPA about the barriers and drivers for beneficial reuse of industrial byproducts in the Gulf Coast States and set the stage for policy dialogues among industry, EPA, and state governments that will encourage further beneficial reuse of industrial materials.

Engineering and Economic Analyses for Ozone-Depleting Substances Sector

Study on the Collection and Destruction of Unwanted ODS in Appliances and Bulk ODS, Multilateral Fund Secretariat and United Nations Environment Program (UNEP) (2007-Present). Mr. Lanza is lead researcher for this project for the Multilateral Fund. The project scope is to review the systems and procedures in place in developed countries to collect and destroy unwanted ODS contained in household appliances and in bulk containers in order to provide guidance on how best to establish appropriate management systems for the treatment of unwanted ODS in developing countries. ICF has developed surveys to collect information from selected developed and developing countries, and has conducted country visits to Australia, Colombia, Canada, the Czech Republic, Germany, India, Japan the United Kingdom, and the United States. Mr. Lanza conducted the country visits to the United Kingdom and Germany, and interviewed German and United Kingdom policy and regulatory agencies and visited appliance recycling, ODS recovery, and ODS chemical conversion facilities. Information was collected concerning the policy and regulatory framework, applied practices and procedures, and infrastructure in each country for management of unwanted ODS. Using the information collected, ICF will develop a final report.

Report on ODS Destruction in the United States and Abroad, U.S. Environmental Protection Agency (2005-Present). Mr. Lanza is providing technical and regulatory analysis support to the U.S. EPA for a report on destruction of ozone-depleting substances. ICF is preparing a report on the current and future status of ODS destruction in the U.S. and abroad. Specifically, the report reviews: the Montreal Protocol decisions relating to the destruction of ODS; the approved technologies for destroying ODS; the U.S. regulations relevant to the destruction of ODS; the characteristics of U.S. facilities that destroy ODS; the historical amounts of ODS destroyed by U.S. facilities; the ability of U.S. facilities to meet the recommended criteria for ODS destruction established by the Montreal Protocol; the future amounts of ODS potentially available for destruction in the U.S. and the capacity of U.S. facilities to destroy it; the costs associated with the destruction of ODS; and the destruction facilities and relevant regulations abroad. For this report Mr. Lanza prepared an assessment of ODS destruction technologies, reviewed ODS destruction unit performance data, and compared the performance data to regulatory standards for hazardous waste combustors (HWCs) regulated under the Clean Air Act MACT Standards and to the TEAP Criteria for ODS Destruction Technologies. Mr. Lanza also prepared an assessment of the methodologies used for performance testing of HWCs and the extent to which such performance testing can demonstrate that HWCs can destroy ODS to the regulatory standards and TEAP Criteria for ODS Destruction Technologies. Mr. Lanza participated in the ODS Stakeholders Workshop conducted by EPA in August 2006, and is also providing technical support to EPA for site visits to ODS destruction facilities.

Analysis of Methyl Bromide Production Processes and Domestic Production Capacity, U.S. Environmental Protection Agency (2004-2006). Mr. Lanza investigated the methyl bromide production processes operating in the U.S. and domestic production capacity for U.S. EPA in order to evaluate the potential consequences of temporary or permanent disruption of domestic production capacity. Mr. Lanza conducted research on the production processes and their associated permit conditions and interviewed representatives of companies that produce methyl bromide and state regulatory agency permit writers involved in permitting methyl bromide production plants to assess the time frame that would be needed to replace domestic methyl bromide production capacity in the event that existing production

capacity was disrupted. Mr. Lanza also conducted research into brominated flame retardant production processes and estimates of the quantities of methyl bromide and other brominated hydrocarbon byproducts produced by these processes.

Technical and Economic Analyses of Recovery, Treatment, and Disposal of Ozone-Depleting Substances, Environmental Protection Agency (2002-2003). Mr. Lanza assisted in preparing a report for the U.S. EPA Significant New Alternatives Program on substitutes for ozone-depleting substances (ODS) and on available destruction technologies for ozone-depleting substances, including rotary kiln incineration, thermal destruction in cement kilns and lime kilns, and non-thermal chemical treatment technologies. Mr. Lanza researched the current techniques being used for ODS disposal, identified and prepared process descriptions for available thermal and nonthermal ODS destruction technologies. Mr. Lanza also assisted in preparing a cost and technical assessment for the California Appliance Early Retirement and Recycling Program of technologies for treatment and disposal of ODS-containing polyurethane foam recovered from recycling used household refrigerators. Mr. Lanza assessed the cost, regulatory, and performance aspects of recovering foam from the used refrigerators, transporting the recovered foam to disposal facilities, and disposing of the foam in municipal solid waste incinerators and municipal solid waste landfills

Infrastructure Siting Studies

Analysis of Petroleum Storage Permitting Options, California Energy Commission (2002-2004). Mr. Lanza is currently assisting the California Energy Commission in assessing regulatory barriers to siting and permitting of petroleum products storage facilities. The project involves identifying and interviewing industry agents who have successfully applied for permit approval, recently entered the siting and permitting process, or have determined that permitting barriers precluded the siting of new storage facilities or expansion of existing storage facilities. The project also involves contacting permitting and other regulatory agencies to assess the permitting process and identify barriers to siting and permitting petroleum product storage facilities. The project summary I identified key areas of the permitting process to investigate in more detail and will include a graphical summary of the steps currently required for, siting, permitting, and construction of a typical petroleum product storage facility. Mr. Lanza has participated in agency workshops and testified before the Commission concerning regulatory issues related to permitting of petroleum infrastructure in California.

Chemical Manufacturing Plant Siting Study, Tioxide PLC, Teeside, Cleveland, England (1992-1993). Mr. Lanza was a principal member of a siting team that conducted an environmental siting study for a major chemical-manufacturing firm siting a new facility in the U.S. The project involved analyses of market factors, resource and infrastructure availability, environmental permitting requirements, geological characteristics, and other criteria related to various alternative sites in eight states. The project objective was to identify appropriate industrial properties for acquisition. Mr. Lanza was involved in every phase of the project since its inception, and prepared a series of reports describing the results of project subtasks. Mr. Lanza obtained information concerning the environmental management practices of the industrial firm's competitors through visits to state environmental offices and interviews with state regulators. Mr. Lanza also assisted in developing siting criteria based on process and facility design information provided by the client, and based estimates of air, wastewater, and solid waste effluents from the proposed facility. Mr. Lanza then met with representatives of state industrial development commissions, the U.S. Army Corps of Engineers, and utility companies to identify available sites meeting the siting criteria, and to identify environmental permitting requirements in the states where potential sites were located. Candidate sites that met the minimum criteria were evaluated using a quantitative ranking system developed by the siting team, based on economic, technical, and regulatory criteria. Results of the quantitative evaluation of the candidate sites were presented by the ICF siting team to the corporate director and design engineering staff in a meeting, in which high-ranked sites were selected for field investigation. The corporate director and design engineering staff and the siting team evaluated the high-ranked sites, met with site representatives, landowners, and state development commission contacts, and

selected a primary and alternate site. Mr. Lanza participated in preparing site development work plans for the two sites. Mr. Lanza and other siting team members also conducted a field evaluation of a third site identified by the client. A site development work plan was also developed for the site.

Technical Support to Siting Commission Concerning Proposed Hazardous Waste Incinerator and Landfill, New Jersey Hazardous Waste Facilities Siting Commission (1988-1998). Mr. Lanza managed preparation of an Environmental and Health Impact Statement (EHIS) for a proposed hazardous waste incinerator and existing hazardous waste landfill expansion for the New Jersey Hazardous Waste Facilities Siting Commission (NJHWFSC). Mr. Lanza also managed additional tasks to provide technical support to the NJHWFSC in a series of public meetings and hearings related to the proposed incinerator and landfill. ICF prepared a preliminary Environmental and Health Impact Statement (PEHIS) in 1989, which involved review of environmental permit applications and process and facility design information related to the proposed hazardous waste units, and assessment of their impacts. Mr. Lanza prepared the assessment of air emissions impacts included in the PEHIS, and assisted in preparation of the health risk assessment analysis. The local community retained a consulting firm to review the PEHIS prepared by ICF, and the consultant's comments were included in a report received by ICF from the local community in 1991. Major comments in the report included the consultant's recommendation of reassessment of the site stratigraphy and groundwater protection measures, reassessment of transportation accident scenarios, and concerns about the environmental and health risks of existing, as opposed to proposed operations at the site. The proposed hazardous waste units were of concern to the local community, and these and other issues were extremely sensitive to local residents and officials. ICF therefore worked closely with the NJHWFSC throughout the project to respond appropriately to public concerns. Mr. Lanza coordinated preparation of additional impact analyses and review and preparation of responses to the consultant's comments. Mr. Lanza also took the lead in preparing comments involving air emissions issues. Draft comment responses were provided to NJHWFSC and to the facility. Finalized comment responses were presented to the local community in a report. Mr. Lanza and other ICF staff represented NJHWFSC in a series of public meetings and hearings. ICF was able to address most of the public comments at these meetings and hearings and demonstrate that the issues raised were not of concern. ICF provided recommendations for mitigative actions in areas where significant impacts related to the construction or operation of the hazardous waste units were identified. Local approval for construction of the proposed incinerator and landfill expansion was received by the NJHWFSC in 1994. The proposed location of the landfill expansion was subsequently revised, and Mr. Lanza managed preparation of an Update to the Environmental and Health Impact Statement in 1998. Final approval of the proposed landfill expansion was issued by the regulatory agency in 2002.

Assessment of Alternative Sites for Proposed Hazardous Waste Incinerator, DRE (1992-1993). Mr. Lanza evaluated several alternative sites for a proposed hazardous waste incinerator in Tennessee and Mississippi that were identified by the facility development and design firm. The site evaluation projects included site visits and evaluation of site topography, physical characteristics, and infrastructure (e.g., road, rail, and utility services). Mr. Lanza also supervised preparation of air dispersion modeling studies for the sites, and prepared an evaluation of public perception issues. One of the preferred proposed sites was 1500 feet from a National Civil War Battlefield Monument, and the proposed site was characterized by high local topography. Air dispersion modeling conducted for this site indicated that the maximum air quality impact would occur within the battlefield monument boundaries. This would be unacceptable from both a regulatory and public perception standpoint, and the site was not recommended for further evaluation. An alternate site was selected by the design firm for further development.

Air Quality Engineering and Permitting

HON Implementation Plan, Hercules Corporation (1996). Mr. Lanza was task manager for preparation of a Hazardous Organic NESHAP (HON) Implementation Plan for an integrated chemical manufacturer. This project involved identification of regulated Chemical Manufacturing Process Units (CMPUs) at the facility, identification and characterization of process and wastewater streams, classification of each

stream as Group 1, Group 2, or exempt under the HON Rule, and development of a detailed compliance strategy for Group 1 and Group 2 streams for incorporation into the HON Implementation Plan. ICF reviewed Process Flow Diagrams with plant process engineers to identify regulated CMPUs and their associated streams. ICF successfully determined that only two of the processes at the plant were classified as CMPUs, and that all but one of the streams associated with regulated CMPUs at the facility was either a Group 2 stream or an exempt stream. ICF's innovative approach to classification of streams and preparation of ancillary calculations allowed the HON Implementation Plan to be completed ahead of schedule, and saved the client capital and operating costs that would have been incurred had the streams been Group 1 streams rather than as Group 2 or exempt streams.

Evaluation of Vendor Bids for SO2/HCl Scrubbers for Proposed Primary Aluminum Smelter Expansion, NSA-Southwire (1998). Mr. Lanza managed the evaluation of vendor bids for SO2/HCl scrubbing systems for a proposed aluminum smelter expansion. Mr. Lanza and engineering staff evaluated five vendor bids based on cost, operability, regulatory compliance, and potential waste generation, and prepared a recommendation for the aluminum smelter design team. This project involved evaluation of existing environmental permits for the facility to assess whether proposed scrubber technologies were capable of meeting existing wastewater discharge permit requirements, and assessment of anticipated air emissions permit requirements for the smelter expansion to assess the compliance capabilities of the proposed technologies. Also, the cost bases for the five vendor bids were all based on differing process assumptions. Mr. Lanza and engineering staff collected additional data from the vendors in order to revise the vendor bid assumptions for the purposes of comparability, and provided recommendations to the client concerning the comparative cost of each proposed system.

Preparation of Regulatory and Technical Assessment of Air Emissions from a Refuse-Derived Fuel-Fired Steam Boiler, U.S. Navy Norfolk Naval Shipyard (1992). Mr. Lanza prepared a regulatory and technical assessment of air emissions from a steam plant firing refuse-derived fuel (RDF) and coal in Virginia. The plant did not comply with air emissions permit limits for several pollutants and had received a notice of violation from the Virginia air pollution control department. In addition to the notice of violation, the RDF facility was also required to respond to proposed air emissions guidelines for existing RDF-fired steam boilers published by the U.S. EPA. The regulatory and technical assessments determined the expected permit limits and control technology requirements for the RDF facility under various operating scenarios. Control technology recommendations were based in part on the results of scheduled air emissions stack tests of the RDF facility. Additional tasks were conducted to implement control technology recommendations included in the technical and regulatory assessments.

Assessment of Electric Utility Air Emission Control Systems for Utility Industry Sector Study, U.S. Environmental Protection Agency (1998-1999). Mr. Lanza was task manager for an U.S. EPA Industry Sector study of the coal-fired Electric Utility Sector. The project involved collecting and evaluating sulfur dioxide and nitrogen oxides emissions data and air emissions permit and operating data for electric utility air emission control systems, including scrubbers, electrostatic precipitators, and fabric filters, and categorizing these data in a database.

Clean Air Act Title V Permit Applications and Modeling Study, University/Hospital Complexes, Georgetown University and The George Washington University (1995-1999). Mr. Lanza managed the preparation of CAAA Title V permit applications for institutional boilers and other combustion equipment at two university/hospital complexes. The project involved preparing emission inventories, CAAA Title V permit application hardcopy forms and electronic forms, and Reasonably Available Control Technology plans for boiler NO_x emission controls. The project also involved proposed construction of new boilers and other combustion equipment in a NO_x non-attainment area, and sensitive negotiation of permit conditions with the regulatory agencies. This project also involved air dispersion modeling of emissions from the institutional boilers to determine compliance with ambient air quality standards. The modeling study was complicated by the location of campus buildings near the boiler house that had building heights approximately equal to the stack heights. Taller stacks could not be constructed for the boilers because

of architectural considerations. Therefore, more refined computer models were required to be used for the modeling study to account for building height effects. Permit negotiations were successfully completed and a permit to construct was issued for the proposed new boiler.

Base-wide Air Permit Application and Modeling Study, U.S. Army (1995). Mr. Lanza managed preparation of a base-wide state air permit application and air dispersion modeling study for a U.S. Army base in Virginia with more than 100 air emissions sources, primarily institutional steam boilers. This project involved collection of source data; preparation of state air permit application forms, emission calculations, and supporting documentation; development of an air dispersion modeling protocol; and conducting base-wide modeling using simple and complex terrain models. Mr. Lanza attended several meetings with state air quality regulators and meteorologists in developing the permitting strategy and modeling protocol for the base. The modeling study involved analysis of more than 900 receptor locations. Emissions calculations determined that the base emissions were only slightly under CAA Prevention of Significant Deterioration (PSD) regulatory thresholds, and the permit application and modeling study were complicated by the state's request that major portions of the federal PSD modeling guidelines be followed despite the facility's regulatory status as a non-PSD source. The modeling study was completed and presented to the state. The study demonstrated that the base operations would not exceed ambient air quality standards.

Air Emissions Inventories and CAAA Title V Permit Applications for Integrated Chemical Manufacturing Plants, Olin Corporation (1995-1996). Mr. Lanza managed an air emission inventory and CAAA Title V permitting project for an integrated chemical manufacturing plant in Kentucky. The permitting project for the Kentucky plant involved identification of both significant and insignificant air emissions sources, identification of air regulations and regulatory exemptions applicable to each source, preparation of air emissions calculations for each regulated source, and preparation of State Title V air permit application forms for the facility incorporating this information. The Kentucky plant, in addition to its manufacturing facilities, operates gas-fired boilers and formerly operated coal-fired boilers. Part of the emission inventory and permitting project was to assess and apply emissions credits from the former coal-fired boilers to the gas-fired boilers, to prepare draft permit conditions for burning waste-derived fuels in the gas-fired boilers, and to assess whether emissions credits can be sold under the CAAA Acid Rain Opt-In Program. The project also involved preparation of an inventory for criteria and hazardous air pollutant emissions for more than 900 air emission sources associated with 12 discrete manufacturing processes. Detailed CAAA Maximum Achievable Control Technology Standard applicability analyses were conducted to determine the extent of applicability of the hazardous air pollutants emission standards to the air emission sources.

Nationwide Permitting Support for Paint Manufacturer, Sherwin Williams Corporation (1997-1998). Mr. Lanza managed the regulatory review and air emissions permitting tasks for a national paint manufacturer, involving 126 paint stores in 43 state and local jurisdictions. Mr. Lanza managed a team of more than 12 engineers in preparing the regulatory applicability determinations for all of the stores. This task involved reviewing all state and local regulations in addition to the federal regulations, and preparing emissions calculations for each store using a proprietary LOTUS spreadsheet program developed by the paint manufacturer. Based on the results of the regulatory assessment and emissions calculations, permit application documentation was prepared for 60 paint stores. A major outcome of the project was that all of the stores for which potential-to-emit made them major sources were able to avoid Title V requirements through the application of selected equipment and operations controls.

Air Emissions Inventories for Polystyrene Manufacturing Plants, Huntsman Corporation (1996). Mr. Lanza managed an air emission inventory project for polystyrene manufacturing plants in six states. The project involved identification of criteria and hazardous air emissions sources at each plant, identification of air quality regulations and regulatory exemptions applicable to each source, and preparation of air emissions inventory calculations for each source. The project was conducted in close coordination with

plant and corporate environmental management to facilitate development of optimal alternative operating scenarios for each plant.

Regulatory Development, Economic, and Lifecycle Analysis Support

Greenhouse Gas Project Feasibility Study, Rhodia Brazil (2005). Prepared engineering calculations for a feasibility study for Rhodia Brazil to evaluate proposed projects involving petrochemical manufacturing process modifications and raw material [feedstock] substitutions that are potentially capable of generating carbon credits. These evaluations involved estimating the lifecycle greenhouse gas emissions reductions for each proposed capital project and evaluation of the greenhouse gas emissions reductions with respect to CDM requirements. Specific process modifications evaluated included analysis of increased self-production of acetic acid using biomass to replace purchased petroleum-based acetic acid, and analysis of greenhouse gas emissions from the production of hydrogen.

Synthesis Report for Research Reports from Combustion Emission Research Grants, U.S. EPA Office of Research and Development, National Center for Environmental Research (2003-2005). Mr. Lanza managed the development of a synthesis report summarizing the research results from five combustion emission research grants awarded under the U.S. EPA Science to Achieve Results program (STAR). Specific tasks included conducting a literature research of current combustion emissions research, developing an outline of the report, managing junior staff in reviewing and summarizing the U.S. EPA combustion research program and grant-funded research results, writing several sections of the report, serving as lead editor and coordinating the compilation and final delivery of the report. The grant-funded research involved investigation of the characteristics of particulate and hazardous air pollutant emissions from combustion sources.

Economic Analyses for U.S. EPA NO_x SIP Call, U.S. Environmental Protection Agency (1998). Mr. Lanza assisted in preparing a memorandum to the U.S. EPA concerning the regulatory schedule for implementation of the NO_x SIP Call for electric utility boilers. The NO_x SIP Call was anticipated to require add-on NO_x emission controls for electric utility boilers. The memorandum evaluated the status of existing and developing NO_x control technologies for electric utility boilers, the anticipated commercialization time frame for developing new control technologies, and current and historical emission control cost data for existing and developing NO_x control technologies.

U.S. EPA Class V Injection Well Study, U.S. Environmental Protection Agency (1999). Mr. Lanza was a principal author of Information Summaries on Class V Sewage Treatment Effluent Injection Wells and Experimental Injection Wells. The Information Summaries were prepared for the U.S. EPA Office of Drinking Water, and included information concerning the inventory of sewage treatment effluent injection wells and experimental injection wells in each state, injectate quality data, data on well construction and operation, best management practices for well construction and operation, and summaries of federal, state, and local regulatory requirements for each injection well category. Data were obtained from questionnaires provided to state underground injection control programs and from literature review and peer reviewers. The Information Summaries also included data on observed environmental impacts of injection well operation on ground water and surface water quality, and a general discussion of the toxicity, mobility, and persistence of the constituents of the injectate for each well category.

Hazardous Waste Management Analyses

Environmental and Health Risk Assessment for Industrial Process Hazardous Waste Incinerator and Hazardous Waste Storage Units, Zeneca, Inc. (1992-1998). Mr. Lanza managed preparation of an Environmental and Health Impact Statement (EHIS) for an existing process hazardous waste incinerator and associated hazardous waste storage vessels at the Zeneca, Inc. Bayonne, New Jersey facility. Mr. Lanza managed development of EHIS protocol, which described the methodologies to be used to conduct air emissions dispersion and deposition modeling, human health risk assessment, surface water,

groundwater, and ecological impact assessment, land use and socioeconomic impact assessment, and foreseeable occurrence and maximum credible accident analyses for incinerator operations. The protocol was developed based on New Jersey Department of Environmental Protection (NJDEP) regulations and guidance, including the New Jersey Solid Waste Management Act. Several meetings were conducted with NJDEP management and technical staff, Zeneca, Inc. environmental engineers, and ICF technical staff to finalize the protocol methodologies. The Bayonne site is located near wetlands and surface water bodies, therefore the EHIS protocol included evaluation of potential impacts to air quality and impacts to water quality, wetlands, and terrestrial and aquatic environments from air emissions deposition. The incinerator operation also involves manual handling of waste containers, and accidental release scenarios analyzed in the EHIS included scenarios related to both incinerator stack emissions and waste handling operations. The ISCST2 and ALOHA models were used to model releases from normal incinerator operations and accident scenarios. The EHIS protocol was submitted to the NJDEP in April 1993 and the EHIS was submitted in February 1994. Mr. Lanza managed a team of eight scientists, engineers, and modelers in the preparation of the EHIS protocol and the EHIS. The NJDEP provided written comments in February 1997 and January 1998, and requested that Zeneca, Inc. perform additional modeling of accidental release scenarios for the hazardous waste storage vessels associated with the incinerator. Mr. Lanza worked with Zeneca, Inc. engineering staff to develop scenarios and modeling procedures for pressure relief valve and pipeline break scenarios. This involved detailed review of incinerator and hazardous waste storage vessel operating data and review of additional data obtained from safety equipment vendors. The NJDEP also requested additional modeling to assess potential impacts to water quality, aquatic environments, and wetlands from deposition of air emissions to sediment, and that additional human health and ecological risk assessment modeling be conducted for potential emissions of chlorinated dioxins and furans from the incinerator. These supplemental analyses involved developing and obtaining NJDEP approval of additional modeling methodologies that were presented to the NJDEP at a series of meetings with Zeneca, Inc. engineering staff and ICF technical staff. Mr. Lanza managed preparation the supplemental analyses, which were provided to the NJDEP in Addendums to the EHIS that were submitted in October 1997 and July 1998 along with a Comment Response Document.

U.S. Drug Enforcement Administration Assessment of Management of Precursor Chemicals in Peru. U.S. Drug Enforcement Administration (2003-2004). Mr. Lanza assisted in conducting an assessment of practices, procedures, and infrastructure used in managing precursor chemicals confiscated from illegal drug laboratory operations in Peru. Mr. Lanza assisted in evaluating field data collected in Peru on current practices, procedures, and infrastructure and in developing recommendations for improving the environmental management practices related to management of precursor chemicals in Peru.

Assessment of Draft Operable Unit Action Memorandum for NASA Jet Propulsion Laboratory, NASA (2003). Mr. Lanza provided review comments to NASA on the Draft Action Memorandum for Operable Unit OU-3 (off-facility groundwater) prepared for NASA Jet Propulsion Laboratory. The draft Action Memorandum documents the NASA decision to conduct a Non Time Critical Removal Action for treatment of off-facility groundwater contaminated with trichloroethene, perchlorate, and carbon tetrachloride. The proposed Removal Action would be implemented by application of a groundwater pump and reverse osmosis treatment system. Mr. Lanza provided comments concerning the application to the proposed Removal Action design of existing and recently acquired off-facility groundwater monitoring data for groundwater wells both inside and outside the proposed capture zone of the groundwater capture system and potential effectiveness of the reverse osmosis treatment system for alternative perchlorate groundwater concentration regulatory end points. Mr. Lanza also evaluated the capital and operating cost estimate for the pump and treat system that was provided in the draft Action Memorandum and assisted in preparing an alternative cost estimate for the system for evaluation by NASA.

Toxic Release Inventory Reporting for Integrated Chemical Plant, General Electric (1998). Mr. Lanza was task manager for preparation of SARA Title III Toxic Release Inventory (TRI) Reports for an integrated

chemical manufacturing plant. The project involved review of process operations and the existing emission inventory and TRI Reports for air, water, and solid waste releases, and preparation of emissions calculations and TRI Reports for the facility. The project also involved developing and reviewing recommendations for process changes and options for reducing waste generation at the facility.

Toxic Release Inventory Reporting for Aircraft Maintenance Facility, Dowty Aerospace (1998). Mr. Lanza conducted review of toxic release inventory reports for metal plating and fabrication facility. The project involved reviewing previously prepared release calculations and TRI reports, revising the facility toxic release inventory, and preparing updated TRI reports. Mr. Lanza provided engineering support to the facility environmental manager during an EPA audit of toxic release inventory reports, and reviewed amended TRI reports prepared by facility in response to EPA audit comments.

Hazardous Waste Facility Permitting

Preparation of RCRA Part B Post-Closure Permit Application for Coal-Tar Manufacturer, Beazer Corporation (1994). Mr. Lanza managed preparation of a RCRA Part B Post-Closure Permit Application and Post-Closure Cost Estimate for two closed surface impoundments associated with a former wastewater treatment system at a coal tar facility in West Virginia. The application described groundwater monitoring procedures and sampling and analysis requirements; contingency, inspection, and training plans; and a cost estimate for the 30-year post-closure operating period. The groundwater monitoring plan for the surface impoundments was developed in part from groundwater monitoring data obtained on site by another division of the firm, and Mr. Lanza coordinated with the on-site project manager to interpret and incorporate the data into the post-closure permit application and cost estimate.

RCRA Part B and Air Emissions Permit Application for Hazardous Waste Incinerator and Inorganic Waste Treatment System in Florida, Florida First Processing Incorporated (1989-1991). Mr. Lanza managed preparation of a RCRA Part B Application, Trial Burn Plan, and Air Permit Application for a proposed hazardous waste incinerator and inorganic waste treatment facility in Florida. Mr. Lanza coordinated efforts with another engineering consultant, whose engineering process diagrams and plans were used to prepare facility and process descriptions. Mr. Lanza also managed preparation of the Waste Analysis Plan, Inspection Plan, Contingency Plan, Personnel Training Plan, and Closure Plan for the proposed facility. Waste management personnel in the new facility=s operations intended these plans as procedural reference. Additionally, Mr. Lanza managed preparation of the Part A Application, a discussion of Procedures to Prevent Hazards, Incinerator Trial Burn Plan, and Closure Cost Estimate for the facility based on RCRA requirements, U.S. EPA and State agency guidance, generally accepted principles, and past experience. Mr. Lanza managed the preparation of air permit applications for the many air emission sources at the proposed facility, including the incinerator, inorganic waste treatment system, materials storage and handling units, and power systems. These applications needed to be prepared on short notice, as a change in regulatory interpretation by the state required simultaneous submission of the RCRA Part B and air permit applications. Mr. Lanza managed preparation of air quality dispersion modeling protocols and prepared emissions calculations and conducted modeling for the air emissions sources. The air permit application addressed emissions of toxic organic compounds and metals, fugitive emissions, and control system technical and regulatory requirements. Mr. Lanza participated in several meetings with Florida RCRA and Air Quality Division regulatory authorities and U.S. EPA Region IV authorities as part of this project. These meetings served to provide information to the State concerning the proposed project and to coordinate preparation of responses to the State's Notice of Deficiency and EPA comments on the draft applications and trial burn plan. In some cases, the EPA's comments and the State's comments conflicted, and these meetings served to identify and work out differences. Mr. Lanza also assisted the client in preparing materials for presentation at public meetings concerning the proposed facility, and has attended a number of such meetings to provide technical support for the client.

Environmental Due Diligence Audits, Compliance Assessments, and Appraisals

Sandia National Laboratory Environmental Management Appraisal, U. S. Department of Energy (1992). Mr. Lanza was a member of an Appraisal Team that conducted a Regulatory Appraisal of laboratory operations at Sandia National Laboratory, Albuquerque, New Mexico. Mr. Lanza reviewed laboratory operations with respect to environmental management, including air emissions, wastewater effluents, waste disposal, and hazardous materials management procedures. Mr. Lanza interviewed laboratory staff and management personnel concerning laboratory-operating procedures, and reviewed environmental management documentation. The Appraisal Team provided briefings to laboratory staff and management personnel concerning the environmental management issues identified, and then prepared an Appraisal Report for Sandia National Laboratory management based on findings and recommendations presented in the briefings.

Sandia National Laboratory NESHAP Appraisal, U.S. Department of Energy (1994). Mr. Lanza and Sandia National Laboratory Environmental Staff conducted a NESHAP Appraisal of operations at Sandia National Laboratory, Albuquerque. The Appraisal Team commenced review of documents approximately two weeks before the appraisal was scheduled to commence. The documents reviewed by the appraisal team before the appraisal commenced included relevant portions of the Environment, Safety, and Health (ES&H) manual, Federal NESHAP regulations and associated methods relating to emission standards for beryllium, radionuclides, and asbestos, relevant sections of the Tiger Team Action Plan (TTAP), NESHAP Radionuclide Compliance Management Plan, and past appraisal reports. The Appraisal Team obtained and reviewed additional documents during the appraisal. These included emissions monitoring data, the NESHAP Annual Report and NESHAP Quality Assurance Program Plan. The Appraisal Team conducted facility inspections and interviews with laboratory staff and contractors during the NESHAP appraisal. The Appraisal Team conducted interviews with the appraised organization management and staff, and interviewed line organization and technical support and oversight organization staffs that either are affected by the NESHAP regulations or have NESHAP compliance responsibilities. The Appraisal Team concentrated facility inspections on radionuclide emissions sources that are continuously monitored or subject to periodic confirmatory measurements under radionuclide NESHAP Subpart H, including radionuclide storage and handling facilities, research facilities and reactors, and radioactive waste management operations. The Appraisal Team also inspected a site where asbestos remediation was being conducted. Decontamination and decommissioning activities at this site were subject to NESHAP Subpart M requirements. The Appraisal Team also inspected a former beryllium processing facility that is no longer in operation. Decontamination and decommissioning activities proposed for this closed facility were subject to NESHAP Subpart C requirements. Mr. Lanza and laboratory environmental staff members of the Appraisal Team prepared an NESHAP Appraisal Report, which described noteworthy practices, deficiencies, and findings with respect to NESHAP regulatory compliance at the laboratory.

DOE Environmental Surveys, Eight Sites Nationwide, U. S. Department of Energy (1987-1989). Mr. Lanza conducted on-site baseline environmental surveys at eight DOE nuclear weapons facilities, energy research facilities, and support operations as part of a multi-disciplinary survey team. The environmental surveys identified major environmental problems existing at the facilities, including radioactive and mixed waste problems, and provided support to DOE for identifying technical, policy and procedural changes optimizing environmental compliance. These surveys included all media and all areas of environmental regulations, including the Clean Water Act, Clean Air Act, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), RCRA, and other statutes. Mr. Lanza was a principal member of the survey team responsible for all air emissions survey activities related to the following facilities: Hanford (Richland, WA); Savannah River Plant (Aiken, SC); Pinellas Plant (Largo, FL); Sandia National Laboratories Albuquerque and associated facilities (Albuquerque, NM); the Solar Energy Research Facility (Golden, CO); the National Institute for Petroleum and Energy Research (Bartlesville, OK); Ames Laboratory (Ames, IA); and the Princeton Plasma Physics Laboratory (Princeton, NJ). Mr. Lanza also functioned as the environmental sampling coordinator for the Savannah River Site, Pinellas

Plant, and Sandia National Laboratory site baseline surveys. Mr. Lanza functioned as a liaison between the DOE National Laboratory sampling and analysis team and the site operations management for sampling and analysis activities conducted for the purposes of site characterization at the three sites. Mr. Lanza coordinated and reviewed requests from survey team members in all disciplines for environmental sampling and analysis related to environmental findings. Mr. Lanza's involvement in the sampling and analysis portion of the project included providing coordination between environmental survey team and sampling and analysis team members; review of preliminary sampling and analysis requests; participation in meetings with representatives of the DOE laboratories assigned to perform the sampling and analysis; and review of final sampling and analysis plans.

Clean Air Act Compliance Audits - Petrochemical Plants, Huntsman Corporation (1991). Mr. Lanza assisted in conducting environmental compliance audits of three petrochemical manufacturing facilities in Texas and Louisiana as part of a multi-disciplinary audit team. Mr. Lanza evaluated the compliance status of each facility with respect to existing air quality regulations and permits, and estimated the potential cost to bring the facilities into compliance with Titles I, III, V and VI of the 1990 CAAA including the Hazardous Organic NESHAP (HON) Rule. Mr. Lanza evaluated the existing wastewater system at each of the plants for existing compliance as well as the impact of the HON Rule and expected future MACT Standards. The costs estimated to comply with the CAAA for the three facilities enabled the prospective buyer of the facilities to lower the buying price by $170 Million.

Property Acquisition and Environmental Audit, Mexico, Rohm and Haas (1994). Mr. Lanza performed an environmental audit of a "Maquiladora" plexiglass manufacturing plant in Matamoros, Mexico. This audit included a detailed review of applicable Mexican environmental regulations, and assessment of air emissions, wastewater discharges, solid and dangerous waste generation and disposal, occupational exposure, and underground storage tank management, and assessment of potential impacts from neighboring manufacturing facilities in the Matamoros industrial park. Mr. Lanza and another project engineer conducted interviews with plant management and staff, inspected the facility while in operation, and inspected the plant expansion that was under construction at the time. Mr. Lanza supervised preparation of the audit report prepared for the prospective buyer of the plant. The report contained a description of the compliance status of the plant with respect to Mexican SEDUE environmental regulations, and described the cost of continued compliance with regulations.

Environmental Permitting and Compliance Assessment of Steel Mills in Indiana, Michigan, and Maryland, Confidential Client (1996). Mr. Lanza performed environmental permitting and regulatory compliance assessments of three steel mills in Indiana, Michigan, and Maryland. Mr. Lanza reviewed air emissions permits and other compliance-related documents for the Indiana facility, and existing and proposed state and federal regulations applicable to steel production facilities to evaluate whether existing air emissions control systems at the facility would meet both current state regulations and expected future regulations under the then-proposed Clean Air Act Amendments. Based on this assessment, it appeared that the existing particulate control systems at the facility would meet expected future requirements of the CAAA for both particulate and toxic air pollutant emission control. Mr. Lanza researched state and federal regulatory review and approval schedules for air emission permits to construct and operate new air emissions sources and control systems for the Indiana and Maryland steel mills. This research was conducted to evaluate the proposed schedules for design, construction, and commissioning of proposed new steel making equipment at the two facilities. Based on detailed review of state regulations pertaining to steel making operations and interviews with state regulators, it appeared that regulatory review and approval schedules for permits to construct air emissions sources exceeded 160 days, and therefore would conflict with the facilities' proposed construction schedules. Mr. Lanza developed an alternative regulatory permitting schedule for each facility based on the results of the research. Mr. Lanza also conducted an environmental compliance assessment of a steel pickling line at a steel mill in Michigan, evaluating compliance with state and federal air emissions, wastewater discharge, and solid waste regulations. This assessment was conducted to evaluate the proposed replacement of the existing line

with a new line of significantly larger capacity. Mr. Lanza inspected the line, interviewed operators of the existing line and design engineers responsible for the proposed new line, and reviewed environmental permits and related regulatory compliance documentation for the existing line. Mr. Lanza also reviewed local, state, and proposed federal regulations applicable to steel pickling and interviewed state and local regulators. Based on this assessment it appears that the proposed new line would meet existing and expected proposed air quality and other environmental regulations.

Property Acquisition and Other Environmental Audits, Multiple Confidential Clients/Locations (1985-1995). Mr. Lanza has conducted property acquisition and environmental compliance and liability audits of industrial facilities, including petrochemical plants, oil field service companies, wire and cable manufacturers, foundries, telephone equipment manufacturers, plastics and plexiglass manufacturers, rendering plants, consumer products manufacturers, aerospace and aircraft parts manufacturers, and pharmaceutical manufacturers. For these audits, Mr. Lanza evaluated current and past environmental management, environmental regulatory compliance; on-site and off-site waste disposal practices; environmental permit status; and overall potential regulatory and economic and liability of present and past operations. Mr. Lanza evaluated the regulatory compliance status of each facility for all pertinent environmental and health and safety regulations and environmental media, including air, wastewater, solid and hazardous waste, hazardous materials and toxic substances, and occupational safety and health, and prepared estimates of the cost of remedial actions that would be required based on the compliance status of the facility. The audits were generally conducted at the request of law firms, banks, or investment firms representing the owner or prospective buyer of the facility. Findings and recommendations, including compliance cost and liability estimates, were provided to the clients in written reports and in telephone briefings.

Environmental Management Systems

Environmental Protection Program Directive, U.S. Department of Energy (2001-2002). Mr. Lanza provided support the DOE Office of Long-term Stewardship in their participation in a Department-wide initiative to develop an Environmental Management System (EMS) Directive for the Department. The Department is developing the EMS Directive to implement Executive Order 13148, Greening the Government through Leadership in Environmental Management. Mr. Lanza reviewed the draft EMS Directive to develop recommendations for incorporating elements of long-term environmental stewardship into the Directive, to facilitate development of procedures for DOE to use in implementing long-term stewardship through the EMS process and a checklist for DOE to use in auditing progress of long-term stewardship activities.

Review of Department of Energy Directives, U.S. Department of Energy (2000-2002). Mr. Lanza reviewed existing DOE Directives and Guidance, including Annual Site Environmental Report Guidance; Lifecycle Asset Management Directive; Facilities Information Management Directive; Nuclear Safety Management regulations; and Real Property Transfer regulations, to identify areas to integrate long-term stewardship and environmental management system elements into the Directives. Elements addressed in the review included pollution prevention, waste minimization, facilities and asset management, and long-term site surveillance and maintenance. Recommendations developed under this task provided the basis for amendments to Directives and procedures to incorporate environmental management system and long-term stewardship elements into the planning and implementation of DOE activities.

Cost and Schedule Estimating Guide, U.S. Department of Energy (1992-1994). Mr. Lanza managed a long-term project for the DOE Office of Waste Management to assist the Office in developing and implementing detailed guidelines for cost estimation and scheduling procedures for ongoing hazardous and radioactive waste management operations at DOE facilities. The project involved collecting data concerning DOE's existing cost estimating, scheduling, and budgeting capabilities at the DOE Field Office level; outlining DOE Headquarters and Field Office requirements for the DOE cost estimation initiative; preparing a detailed guidance document on cost and schedule estimating procedures applicable to all

DOE radioactive and hazardous waste management operations; and presenting senior management briefings and management training at eight DOE sites. The project also involved assisting DOE in developing agency-wide policies on use of contingency in cost estimates for waste management operations and in developing and on implementing cost estimate review and assessment procedures coordinated with DOE's annual budget cycle. Mr. Lanza managed a staff of six engineers, scientists, and cost estimators on this project, managed preparation of the Guide, and delivered training at DOE facilities. Mr. Lanza developed experience in guidance document and training program development and implementation through his involvement in this project, and developed a detailed knowledge of DOE hazardous and radioactive waste management organizations and programs, management and budgetary systems, and directives related to hazardous and radioactive waste management operations.

Long-term Environmental Stewardship

Long Term Stewardship Study, U.S. Department of Energy (1999-2001). Mr. Lanza was task manager for a study of long-term stewardship issues at DOE facilities. The purpose of the Long-term Stewardship Study is to set out the facts about the human health and environmental hazards that will remain at DOE sites after environmental restoration of the sites is completed, issues that DOE needs to address and attempt to resolve in its future long-term stewardship efforts, the types of activities that DOE will undertake, and the resources that will be required to support DOE's stewardship efforts. ICF assisted the DOE Environmental Management Program in all phases of this project, from planning and public scoping to developing the draft study, public comment on the draft study, and developing the final study. Mr. Lanza assisted in developing the scoping and public involvement processes for the draft and final study, including the Notice of Intent, comment response plan, and background documentation for the study. Mr. Lanza has also performed literature searches and prepared technical and regulatory analyses related to long term stewardship study issues, and assisted in developing the study plan and sections of the study related to hazard management, engineered and institutional controls, real property management, funding and financial management, and natural and cultural resources management.

Long-term Stewardship Case Studies, U.S. Department of Energy (2001). Mr. Lanza managed preparation of the Final Draft Long-term Stewardship Case Study Report, which analyzed seven DOE programmatic and site-specific management decisions with respect to long-term stewardship. The decisions analyzed related to site remediation, site-specific and programmatic waste management, mission siting and design, and real property transfer. The analyses were conducted to identify how, and to what extent, long-term stewardship considerations factored into the identification and evaluation of alternatives and DOE decision-making processes. The objective of the analyses was to highlight lessons learned from these decisions in order to make recommendations, inform future DOE decisions, and improve the integration of long-term stewardship into DOE decision making processes. Mr. Lanza managed preparation of the draft report, coordinated responses to headquarters and field element comments, and managed preparation of the Final Draft report.

Long-term Stewardship Report to Congress; U.S. Department of Energy (2000-2001). Mr. Lanza assisted in preparing the Report to Congress on Long-term Stewardship, published by DOE in January 2001. Mr. Lanza collected and evaluated data concerning site-specific long-term stewardship activities and costs and prepared draft site-specific report sections for more than 24 sites in the DOE long-term stewardship program. Mr. Lanza also assisted in preparing a CD-ROM database of site-specific maps and related long-term stewardship information for the Report to Congress.

SELECTED PUBLICATIONS/PRESENTATIONS

Lanza, R; Martinsen, T; Mohammed, Dr. A. K. W; Santos, M; Neelis, M; and Patel, M. Intergovernmental Program on Climate Change (IPCC), 2006 IPCC National Greenhouse Gas Inventories Guidelines, Petrochemical and Carbon Black Production (Principal Author)

Lubetsky, J; Steiner, B, Lanza, R., Intergovernmental Program on Climate Change (IPCC), 2006 IPCC National Greenhouse Gas Inventories Guidelines, Iron and Steel and Metallurgical Coke Production, 2006 (Contributing Author)

Freed, R., Lanza, R.; Mintz, C.; Analytic Framework for Analyzing Non-Energy Uses of Fossil Fuels as Petrochemical Feedstocks in the USA, in Resources, Conservation Recycling Special issue: CO_2 Emissions from Non-energy Use of Fossil Fuels - Edited by M. Neelis and M. Patel, 2006

Freed, R., Lanza, R., Gillenwater, M. Non-Energy Uses of Fossil Fuels: US GHG Inventory Methods and Results. Presented at the Third NEU-CO_2 Workshop: Non-Energy Use and CO_2 Emissions -- Paris. 2001.

PROFESSIONAL AFFILIATIONS

Professional Engineer, Maryland (1997)

American Institute of Chemical Engineers

National Society of Professional Engineers

SECURITY CLEARANCES

Q Clearance with the U.S. Department of Energy (Inactive)

EMPLOYMENT HISTORY

ICF International, Principal Chemical Engineer, Principal Chemical Engineer, Lead Chemical Engineer, Senior Associate	1985-present
Martin Marietta Environmental Systems: Senior Environmental Engineer	1984-1985
Martin Marietta Environmental Center: Environmental Engineer	1982-1984
Combustion Engineering Env. Systems: Development Engineer	1980-1981

BOB RUSSELL **ICF INTERNATIONAL**

EDUCATION

M.S., Chemistry / Polymer Science, Central Michigan University, 1978
B.S., Chemistry, Adelphi University, 1973

EXPERIENCE OVERVIEW

Bob Russell is a Senior Technical Analyst and Foam Sector Expert with ICF. He has over 20 years of technical and regulatory experience in insulation foams and serves as a member of UNEP's Foams Technical Options Committee. Previously, Mr. Russell was a Technical Director for Dow Chemical in the insulations foams business. His knowledge transcends across several insulation foam categories such as XPS (Extruded Polystyrene), PUR (Polyurethane) and PIR (Polyisocyanuarate) foam products. In addition, he has worked in the area of ozone-depleting substances (ODS) and GWP-reducing substitutes across many product sectors, including foams. Mr. Russell has conducted past LCCP studies on foams used in residential and commercial building construction applications across blowing agents similar to those being analyzed in this study. He is also knowledgeable of the value of LCCP analysis results in highlighting the benefits of foam insulation products and their corresponding blowing agents to regulators and the International Community. Mr.Russell has worked on several projects supporting the U.S. EPA's Global Programs division on projects involving ODS and GHG analyses. He holds a BS in Chemistry from Adelphi University and an MS in Polymer Science from Central Michigan University.

SELECT PROJECT EXPERIENCE

RJR Consulting Inc., President (1999-Present). Provides technical, business and regulatory consulting to government agencies and the private sector. Responsible for business startup/development, P&L, marketing, sales, and project research. Focuses on optimizing business performance and minimizing regulatory compliance by developing "creative value platforms." Conducts third-party technology, manufacturing assessments and reviews. Offices in Michigan, Washington, DC and Brussels, Belgium.

Honeywell International Inc. (1996-1999). *Global Director of Regulatory Affairs, Specialty Materials.* Served on Global Leadership Team. Responsible for P&L, strategic planning, growth and accountability. Ensured global regulatory compliance at the Corporate level including Europe, Asia, Canada, and North America. Represented company globally at key United Nations Protocol Meetings.

DOW Chemical Company (1973-1996). Global Director, Environmental and Legislative Affairs (May 1990-September 1996). Responsible for P&L, strategy, implementation, and growth / extended phase-out of key raw materials tied to ozone depletion/global warming impact. As Chairman of Dow's Global Climate Change Team, set up company plan, then implemented course of action to minimize impact. As member of Corporate Public Policy Team, provided Issue Management guidance on major health and environmental impact issues for the company.

R&D – Foam Products, Director (1987-1990). Chaired multi-functional business team of 70 people in R&D, marketing, sales, manufacturing, and supply chain. Led the phase-out of CFC blowing agents in Foam products. Managed Pilot Plant Operations, technical services, and plant support. Served as Chairman of the Site Safety Program.

New Business Development, Manager. (1984-1986). Responsible for overhauling New Product Development Process from idea creation to commercialization for key customers and accounts. Increased focus of all functions on growth through internally developed new products, systems, and services. Developed 5-year plan with annual targets for revenue from sales of new products, and specified necessary resources.

Prior Dow experience included progressive responsibility from Polymer Chemist through R&D Manager.

PROFESSIONAL AFFILIATIONS

Alliance for Responsible Atmospheric Policy, Chairman of the Board (3 years); ASHRAE, Current Board of Trustees

National Institute of Building Science, Past Board Member; Foam Polystyrene Alliance, Past Board Member

International Climate Change Partnership, Past Board Member; International Chamber of Commerce

United Nations Foams Technical Options Committee

PHILIP GROTH

ICF INTERNATIONAL

EDUCATION

Master of Planning, University of Southern California, Los Angeles, California, 2006
Bachelor of Arts, Anthropology, Williams College, Williamstown, Massachusetts, 2000

EXPERIENCE OVERVIEW

Mr. Groth joined ICF International's Climate Change Strategy Practice in 2001. His work has primarily focused on greenhouse gas emissions inventory models and climate change outreach for clients such as the U.S. Environmental Protection Agency. Mr. Groth assists with the technical development of applications and models using Visual Basic for Applications (VBA) and Microsoft Excel. He has extensive experience developing and maintaining spreadsheets and databases, performing literature- and Internet-based research, and writing and editing technical and outreach-oriented documents. Since completing his Master of Planning degree, he is working to integrate his climate change experience with the challenges and opportunities of place-based planning.

Prior to joining ICF International, Mr. Groth worked on environmental issues in a wide variety of capacities. He has worked for an environmental advocacy non-profit organization and for the environmental affairs practice at a communications firm. He also has experience with a planning agency in western Massachusetts. In 1999, he conducted an independent research project on modern and traditional agricultural practices in Bali, Indonesia. He recently completed a Master of Planning degree at the University of Southern California. His coursework included transportation planning and management, environmental planning, smart growth, demography, international development, and GIS.

SELECT PROJECT EXPERIENCE

Vintaging Model, U.S. Environmental Protection Agency. Mr. Groth is currently assisting with the development and improvement of the U.S. EPA's Vintaging Model as a lead programmer. Using market data about various products, the model creates a ground-up estimate of the use and emissions of ozone depleting substances (ODSs) and ODS substitutes from 1985-2030 in a variety of sectors, including refrigeration, fire extinguishers, foams, aerosols, and solvents. While the old version of the Vintaging Model was developed using Quattro Pro. Mr. Groth developed the code for an updated Microsoft Excel version of the model. He is now working with other team members to add additional functionality and flexibility to the model, extend the model's calculation timeline to 2100, and streamline the model's performance. In 2001-02, he helped develop a smaller, user-friendly version of the Vintaging Model that focuses on motor vehicle air conditioners.

Fluorinated Greenhouse Gas (F-Gas) Reporting Forms and Summary Template, European Commission. Mr. Groth assisted with the development of reporting forms to be used by producers, importers, and exporters of F-gases regulated under Regulation (EC) 842/2006 in the European Community. The forms capture comprehensive data on the production, import, and export of F-gases as well as quantities placed on the EC market in various sectors of use and quantities destroyed and reclaimed each year. Mr. Groth helped develop the user interface and added interactive features using macros written in VBA.

Compliance with Reporting and Recordkeeping Requirements, U.S. Environmental Protection Agency, Stratospheric Protection Division. Mr. Groth has assisted with the development of the U.S. EPA's Stratospheric Ozone Protection Program's reporting forms to be used by companies that produce, import, export, request additional consumption allowances, and trade Class I and Class II controlled substances. His work has focused on adding interactive features to improve the user interface and streamline the collection process using macros written in VBA.

Integrated Climate and Land-Use Scenarios, U.S. Environmental Protection Agency. Mr. Groth is working on an ambitious project with the U.S. EPA and the Natural Resources Ecology Lab (NREL) at Colorado State University to develop a series of detailed population and land use scenarios for the next 100 years. His work includes developing a demographic model in Visual Basic that estimates annual county-level population using a cohort-component model augmented by a gravity model to estimate domestic migration. In developing this population model, Mr. Groth has used a variety of demographic techniques and analyzed raw Census data using SAS. He is currently working with NREL to integrate this population model with NREL's SERGoM (Spatially-Explicit Regional Growth Model).

California Marginal Abatement Cost Curves; California Energy Commission. Mr. Groth helped assess the feasibility of and cost associated with GHG reduction initiatives across various economic sectors in California. He assisted in the 2006 update to the original 2005 report. His duties included modeling current and future emissions, estimating costs for reduction technologies, providing technical support for the Excel-based model, incorporating policy changes into the study methodology, and updating the report with the revised results and methods.

International Marginal Abatement Curve for ODS Substitute Emissions, U.S. Environmental Protection Agency. Mr. Groth provided technical support to the International Marginal Abatement Curve (IMAC) project. He helped program the Hi-GWP Model, which generates marginal abatement curves (MACs) for industrial sectors and ozone-depleting substance substitutes. He worked closely with sector experts and the project managers to keep the latest data in the model. He was also responsible for developing the code necessary to generate the outputs requested by U.S. EPA. This required utilizing Visual Basic and Microsoft Excel to perform complex manipulation and calculation of economic and emissions data. He also used the IMAC model to generate cost curves and emission projections for a wide variety of sectoral, regional, and economic scenarios. He then synthesized the results in tabular and graphical form.

Road Home Louisiana, State of Louisiana. Mr. Groth provided data management and technical support to the project's Homeowner Program, the largest post-disaster assistance program of its kind. While facing political pressure to deliver assistance checks to hurricane victims and faced with a lengthy software development process, Mr. Groth developed a series of simple and effective tools for processing application data, assessing application completeness, and calculating grant amounts. This allowed the program to process applications while the permanent system was still under development.

Updates to the City of Los Angeles Climate Action Plan, City of Los Angeles. Mr. Groth is supporting the City of Los Angeles' Climate Action Plan in a variety of contexts. The City is currently developing a Year 2004 update to the original Year 1998 plan. Mr. Groth is assisting with the evaluation of a wide range of proposed emission reduction actions. He helped developed the screening criteria for evaluating these measures, then evaluated and ranked the measures based on the criteria. He then developed detailed analyses of the emission reduction potential of six selected measures, and provided other assistance based on requests from the City. He is currently helping write the updated Climate Action Plan.

Commission Briefing Paper, Federal Highway Administration. Mr. Groth co-wrote a paper evaluating surface transportation-related strategies to reduce mobile source GHG emissions for the National Surface Transportation Policy and Revenue Study Commission. Mr. Groth summarized technology-, fuels-, and behavior-based options for reducing GHGs from mobile sources and related policy mechanisms.

Leadership in Energy and Environmental Design – Neighborhood Development (LEED-ND) and Climate Change; U.S. EPA. Mr. Groth is assisting with an analysis of the stormwater management performance of Smart Growth-style neighborhood developments under a variety of precipitation scenarios. This work demonstrates the potential benefits associated with climate change adaptation of the proposed LEED-ND standards by the U.S. Green Buildings Council. His duties include collecting and analyzing historic precipitation data for 9 U.S. cities, modeling future precipitation scenarios, analyzing the results of the stormwater pollutant modeling exercises, and incorporating the methods and results into a paper.

Climate Change Research Plan, California Energy Commission (CEC). Mr. Groth is helping update the CEC's five-year Climate Change Research Plan and a related program brochure. This work is being performed under the Public Interest Energy Research (PIER) program, which supports and coordinates California-focused climate change research. Mr. Groth's duties include reviewing studies conducted under PIER and synthesizing the findings and the current status of the research plan in publications for a variety of different audiences.

State Inventory Tools and Guidance, State and Local Climate Outreach Program, U.S. Environmental Protection Agency. Mr. Groth has been a lead developer of a suite of Microsoft Excel-based tools that help states estimate GHG emissions from different sectors. These tools automate the inventory methodologies prepared for the Greenhouse Gas Committee of the Emission Inventory Improvement Program (EIIP). Working in conjunction with experts on the respective sectors, Mr. Groth has developed tools for the following sectors: CO_2 from Fossil Fuel Combustion, Stationary Non-CO_2, Mobile Non-CO_2, Coal Mining, Oil and Natural Gas Activities, Industrial Processes, Agriculture, Land-Use Change and Forestry, Municipal Solid Waste, and Waste Combustion. He has linked default data to methodologies provided by the sector experts and provided the Visual Basic programming to create a user-friendly environment and export the results to a "Synthesis Tool." Mr. Groth also led the development of a Projection Tool. This tool calculates state-by-state GHG emission projections for the years 2001-2020. Using emission data from the State Inventory Tool, national emission projections, population projections, and energy consumption projections, this tool helps states quickly project emissions using default data while also allowing maximum flexibility and the incorporation of state-provided data. During this project, Mr. Groth has developed a working knowledge of the 1996 Revised IPCC Guidelines, the IPCC Good Practice Guidance, and the EIIP Guidance for all sectors. He also assisted with a thorough review and revision of the Industrial Processes chapter of the EIIP Guidance documents. He compared current EIIP Guidance methodology with the IPCC and U.S. Inventory methodologies and revised the EIIP Guidance to reconcile the differences.

Climate Leadership in Public Places Tool (CLIPP), U.S. Environmental Protection Agency and National Park Service. Mr. Groth helped lead the development of CLIPP, an Excel-based tool that helps National Parks inventory their GHG and criteria air pollutant emissions from a variety of sources and plan reduction strategies in both scenarios. Mr. Groth was involved with the design, development, and refinement throughout the entire process. He assisted with the initial selection of emission sources, inventory methodologies, and mitigation options. He then designed the overall structure of the tool, including a modular tool architecture that will allow this tool to be adapted for use by other institutions in the future. Finally, he directed a team of programmers and sector experts in developing the individual sections of the tool. Mr. Groth then participated in the refinement of the original CLIPP tool and the development of a schools module designed as both a teaching and inventory tool for High Schools.

Montreal Protocol GHG Emissions Tool, Australian Greenhouse Office. Mr. Groth and his colleagues at ICF worked with the Australian Greenhouse Office to develop a tool that uses required industry reporting on imports of ODS-Substitutes to generate emissions inventories. Mr. Groth served as the lead technical developer in this project, providing the Excel framework and Visual Basic programming for the tool. He also assisted with the development of the methodology used in this tool.

Analysis of CFC Supply and Demand in Developing Countries for the European Commission, European Commission Directorate-General of the Environment. Mr. Groth assisted with a report examining the EU program for supplying CFCs to Article 5(1) countries. The objective of the report was to determine if reduced supply levels are appropriate to meet Montreal Protocol objectives, while ensuring consistency with EC policy directives. Mr. Groth provided quantitative and modeling support by maintaining and improving a model that uses historical trends, policy targets, reduction projects through the Multilateral Fund, and other industry data and assumptions to project worldwide supply and demand through 2010.

National GHG Emission Inventory for the United States, U.S. Environmental Protection Agency. For the 1990-2000 Inventory, Mr. Groth conducted a detailed analysis of the spreadsheets used to compute the carbon intensity of energy consumption by end-use sector. He also assisted with the Land Use Change and Forestry chapter by analyzing research and writing passages about emissions from yard trimmings and changes due to the conservation of agricultural land through federal programs. He investigated the carbon stocks in U.S. trees that are currently not covered by the forest and urban tree sections and researched activity data for the Industrial Processes sector. Using this new data, he then updated and improved the Industrial Processes spreadsheet and chapter. He has also assisted on numerous discretionary tasks in various sections of the Inventory. Mr. Groth has also played an integral role in preparing the National GHG Emission Inventory for submission to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC). Mr. Groth has been responsible for developing, maintaining, and running software that integrates the U.S. EPA's inventory files with the Common Reporting Format (CRF) as provided by the UNFCCC. He has also assisted with the QA/QC and formatting of the final CRF submissions.

Climate-Friendly Decions, State and Local Climate Outreach Program, U.S. Environmental Protection Agency. Mr. Groth has provided to support to several projects under the U.S. EPA's State and Local Climate Change Program. Mr. Groth has gathered information and helped write sections of the Climate-Friendly Decision Guide for Policymakers, a publication designed to help state and local leaders take greenhouse gas effects into consideration when making common policy decisions. He has focused on technical research of the various policy options and the effects and helped develop statistics demonstrating the benefits of "climate-friendly" policies.

Green Buildings Material Emission Factor Development, U.S. Environmental Protection Agency. Mr. Groth conducted research on the feasibility of developing product-level emission factors for concrete and asphalt roofing shingles. In the preliminary phase of the project, Mr. Groth gathered data on the lifecycle energy consumption and greenhouse gas emissions of concrete (focusing on cement, fly ash, and aggregate) and asphalt roofing shingles through internet and literature research and interviews with industry experts. Mr. Groth then used the data to develop lifecycle emission factors for concrete and recycled-content concrete and synthesize the results in a report. In a follow-up project, Mr. Groth contacted industry experts to develop estimates on the generation, disposal, and recycling rates of concrete and asphalt shingles. The results of these research projects were presented to the U.S. EPA and are currently awaiting peer review.

Emissions Factor Database Support, U.S. Environmental Protection Agency. Under the U.S. EPA's Methane and Sequestration Branch, Mr. Groth research and compile greenhouse gas emission factors for inclusion in the International Panel on Climate Change's (IPCC) Emission Factor Database. For this project, Mr. Groth reviewed scientific literature for emission factors developed to measure methane and nitrous oxide emissions from biomass burning and cook stoves in developing countries. He has also developed a database that was used to organize and prepare data for submission to the IPCC database.

GHG Emission Inventory Assistance to Developing Countries, U.S. Environmental Protection Agency. Mr. Groth assisted the U.S. Country Studies Program with a thorough review and improvement of technical assistance materials intended to aid countries in compiling their own national greenhouse gas inventories. He worked to adjust the materials to reflect improvements in GHG inventory methodology outlined in the International Panel on Climate Change's 2000 Good Practice Guidance manual.

Aluminium HGWP IMAC Model, U.S. Environmental Protection Agency. Mr. Groth has provided support to the model that generates international marginal abatement curves (IMAC) for emissions of high global warming potential (HGWP) gases from Aluminum production. Mr. Groth was responsible for providing the programming and reorganizing the model's structure in order to transform it into a user-friendly tool capable of rapidly generating useful economic data.

KATRIN MOFFROID ICF INTERNATIONAL

EDUCATION

M.S., Natural Resources, *Environment, Society, and Public Affairs*, University of Vermont, Burlington, VT, 2006
B.A., Geography and Biology, *Cum Laude*, Colgate University, Hamilton, NY, 1999

EXPERIENCE OVERVIEW

Katrin Moffroid is a Senior Associate in ICF International's Energy and Resources Practice, where she has eight years of consulting experience investigating the technical and policy aspects of a broad range of environmental issues. At ICF International, Ms. Moffroid has been involved primarily in work on greenhouse gas emissions and stratospheric ozone depletion research and analysis in support of the Environmental Protection Agency. She has extensive experience estimating emissions, conducting research, writing technical and scientific documents, preparing presentations, collecting and analyzing data, and developing and operating computer models.

SELECT PROJECT EXPERIENCE

Inventories and GHG Estimates

Inventory of U.S. Greenhouse Gas Emissions and Sinks, U.S. EPA (1999-2004). Ms. Moffroid prepared emission estimates from CO_2 and CH_4 emissions from industrial processes and ODS substitutes. Ms. Moffroid also supported the general document synthesis and quality checking processes. The U.S. Greenhouse Gas Inventory is compiled for U.S. EPA and submitted annually by the U.S. State Department to the United Nations Framework Convention on Climate Change (UNFCCC).

California Inventory of Greenhouse Gas emissions and Sinks, California Energy Commission (2001). Ms. Moffroid was responsible for preparing estimates of emissions of methane and nitrous oxide from manure management and enteric fermentation for the state inventory of California. This involved determining the appropriate method and developing the spreadsheets to calculate emissions. Additionally, she prepared the accompanying text for both sections, describing background information, methods, results, and data sources.

Marginal Abatement Cost Curve, New Zealand Ministry for the Environment (2006-2007). Ms. Moffroid was the lead for developing cost and reduction opportunities for enteric fermentation for the report *Analysis of the Potential and Costs for Greenhouse Gas Emission Reductions*. In addition, she was the lead for generating the marginal abatement cost curve output for all included sectors, and for compiling the final report to document methodologies, assumptions, and results. The purpose of the report and the corresponding tool was to develop a framework for comparing greenhouse gas emission mitigation options for key sectors in New Zealand, for use in developing future policy options.

International High-GWP Cost Curve Report, U.S. EPA and IEA (2001-2004). Ms. Moffroid updated a model used to predict ODS substitute use and emissions from developed countries and prepared a model that predicts use and emissions of ODS substitutes from developing countries, for use in the international high-GWP cost curve report. The model incorporated growth rates, predicted differences in substitution scenarios, alternate substitution timing factors, and other predictor mechanisms to estimate use and emissions of ODS substitutes in developed and developing countries based on the U.S. transition.

Estimation of Emissions from Enteric Fermentation, U.S. EPA, 2000-2004 (2007). Ms. Moffroid was the Task Order Manager for this project. She was responsible for maintenance and improvements for a Microsoft Excel model designed to estimate emissions due to enteric fermentation from cattle. This

includes an enhanced population characterization module that tracks cattle by month through each phase of their lifecycle. Additionally, the model uses diet characteristics to estimate emissions, volatile solids, and nitrogen excretion, among other outputs. Ms. Moffroid also has prepared the detailed description of the methodology and model instructions, as well as the results, for incorporation into the *Inventory of U.S. Greenhouse Gas Emissions and Sinks.*

Development of Spreadsheet Tool to Estimate Greenhouse Gas Emissions from Agricultural Sources, U.S. EPA (2001-2004). For the U.S. EPA's State and Local Climate Change Program, Ms. Moffroid assisted in the development of an excel-based spreadsheet tool for use by states to estimate emissions of methane and nitrous oxide from agricultural sources. Ms. Moffroid was responsible for revising and quality-checking the sections on emissions from manure management and enteric fermentation. This tool is designed to allow states to estimate emissions with minimal expenditure of time and money. All available default animal population data, emission factors, manure management system percentages and other variables are available for each state, or alternatively the state can input data and the emission calculations will develop estimates on the parameters given.

Update of Livestock Analysis Model, U.S. EPA (2003). Ms. Moffroid updated U.S. EPA's Livestock Analysis Model and the corresponding guidance document to follow the IPCC's 2000 *Good Practice Guidelines and Uncertainty Management in National Greenhouse Gas Inventories.* This model and guidance provides a tool to evaluate the impact that changes in cattle productivity, such as diet, health, or population, can have on emissions.

Emissions Inventory Improvement Program Guidance for Agricultural Sources, U.S. EPA (2002-2004). Ms. Moffroid was the lead on developing and writing the revised methodology for the Emission Inventory Improvement Program (EIIP) guidance to states for estimating emissions methane and nitrous oxide from manure management and enteric fermentation. The goal of this revision to the EIIP guidance was to allow states to easily assess their emissions by source and to be able to be consistent with the US Inventory methodology, wherever possible.

Development of Historical Estimates of Greenhouse Gas Emissions, U.S. EPA (2002). Ms. Moffroid collected and evaluated appropriate historical data and developed spreadsheet models to estimate emissions of methane and nitrous oxide from manure management and methane from enteric fermentation from 1850 to present day.

Common Reporting Form for the Inventory of U.S. Greenhouse Gases and Sinks, U.S. EPA (2000-2004). Ms. Moffroid served as one of the leads in completing the Common Reporting Form (CRF) tables for the U.S. Greenhouse Gas Inventory, specifically the tables for industrial processes, agriculture, waste, solvents, and some of the overall summary and explanation tables. She has also implemented a series of QA/QC checks to ensure that each individual sector and the CRF tables as a whole are filled out with the correct Inventory data. The electronic CRF tables were requested by the Intergovernmental Panel on Climate Change beginning with the 1998 Inventory submission. The CRF tables require that all numerical data associated with the written Inventory submission, including activity data, emission factors, and emission estimates, are documented in a series of complex Excel spreadsheets.

U.S. Inventory QA/QC Plan, U.S. EPA (2000-2001). Supported the development of a plan to implement a set of Quality Assurance/Quality Control Procedures for the Inventory. Ms. Moffroid drafted a section on US Inventory steps for development, and helped develop checklists of procedures to follow, guidelines for review processes, and other QA/QC activities.

Presentation of Inventory Methods, U.S. EPA (2000). Assisted in the development of a set of "organograms," graphic representations of the flow of information in Inventory emissions-estimation processes. Gained familiarity with the graphic tools of Excel and in creating portable document format

(pdf) files. This tool was used to communicate ICF/EPA Inventory protocol to officials from the UN Framework Convention on Climate Change.

Ozone Depleting Substances and Substitutes

Maintenance of ICFs Vintaging Model to Estimate Emissions from ODS Substitutes, U.S. EPA (1999-2004). Ms. Moffroid helped to maintain a detailed, bottom-up Vintaging Model that tracks and projects emissions from ozone depleting substances and their substitutes in each of the Montreal Protocol industries within the United States based on equipment in place, leak rates, charge sizes, and other variables. This tool is used to develop US HFC emission estimates from ODS substitutes for the US Inventory, cost curve analysis, and other documents. Additionally, she uses this information to project HCFC consumption to insure that the US remains under the HCFC Cap designated by the Montreal Protocol.

Mobile Air-Conditioning Vintaging Model, U.S. EPA (2000-2002). Helped develop a Microsoft Excel model to calculate emissions from motor vehicle air-conditioning (MVAC) systems. Designed after the original Vintaging Model, the MVAC model allows for greater flexibility in the input and output and has a more user-friendly interface system so that it can be adapted for use in countries other than the United States.

Ozone Hotline Frequently Asked Question Database, U.S. EPA (2001-2002). Ms. Moffroid was the Work Assignment Manager for the development of a searchable question-and-answer Lotus Notes database of stratospheric ozone protection information to support EPA's ozone hotline. The database provides supplementary information on topic and subtopics, EPA staff contact, contact phone number, relevant EPA documents, Internet links to EPA documents, and other relevant references. Questions and responses were categorized and grouped according to the topic and subtopics and covered issues relating to relevant ozone-related topics. The search functions allowed viewing of entire topics or subtopics, or searching for specific key words or phrases to find an answer to a specific inquiry.

Regulatory support for HCFC rulemakings, U.S. EPA (2002-2004). Ms. Moffroid was the Work Assignment Manager in support of a petition process in the final HCFC allowance allocation rule, in order to allow a limited amount of production or import of HCFC-141b after January 1, 2003 to fulfill the needs of the industry. This Work Assignment also supports various rulemakings associated with the chemical-by-chemical phaseout, beginning with January 1, 2003. In addition, this work provides verification of documentation of HCFC import activity for individual companies from 1994 to 2000.

Ozone Depleting Substance Tracking System, U.S. EPA (2002-2004). Ms. Moffroid was the Work Assignment Manager for the maintenance of the database used to track the ozone depleting substance use in the United States. The database is used to track the production, consumption, and destruction of ODS on an annual basis, based on quarterly submissions from individual companies. This Work Assignment provided support to EPA to improve the user-friendliness of the database, as well as to trouble shoot any issues that arise.

Preparation of Methyl Bromide Critical Use Exemption Cost Benefit Analysis, U.S. EPA (2003). Ms. Moffroid oversaw the transition of the original methyl bromide cost model into a more user-friendly macro-driven model that estimated the cost savings from allowing additional consumption of methyl bromide past the 2005 phaseout deadline. Ms. Moffroid than used the model to compare the baseline scenario with two critical use scenarios that allocated methyl bromide to specific crops.

Preparation of Methyl Bromide Regulatory Impact Analysis, U.S. EPA (1999-2001). Ms. Moffroid helped develop and maintain a computer model to determine the costs associated with implementing a phaseout of methyl bromide. The model calculates revenue change for each of fifteen crops and nine regional areas based on cost and yield changes, market shares, acres in use, and substitutes available. In

addition net present value is calculated and used for comparison with the monetized benefits of the phaseout.

Data Collection and Analysis of Aerosols Sector to determine impact of the California VOC regulations, U.S. EPA (1999). Based on extensive phone interviews with industry experts and web-based literature searches, Ms. Moffroid researched implications of limiting volatile organic compound (VOC) propellant in specific aerosol products. She then developed estimates of the impacts that reductions in VOCs would have on emissions of GWP gases, such as HFC-152a, that will be used to replace them. Additionally, she assisted in the preparation of a memorandum for EPA's Stratospheric Ozone Protection Division detailing the results of this research.

Assessment of Worldwide Elemental Bromine Supply, U.S. EPA (2000). Ms. Moffroid examined historical global bromine production and consumption. She also conducted research on solvent production and prepared a memorandum that included possible scenarios for using n-propyl bromide as a substitute in solvent end-uses.

Research Hydrocarbon Use in the Refrigeration and Air-Conditioning Sectors, U.S. EPA (2000). As part of a report on hydrocarbon use for refrigeration and air-conditioning in developed and developing countries Ms. Moffroid assisted in gathering data, interviewing experts, and conducting extensive internet searches for information pertaining to North America. Additionally she drafted and edited the section of the report on this geographical region.

Cost/Benefit Analysis of HCFC Allowance Allocation Program, U.S. EPA (1999-2000). In support of EPAs proposed HCFC allowance allocation program Ms. Moffroid assisted in the development of the cost inputs to determine the estimated impact that this regulation would have for both industry and EPA. Furthermore, Ms. Moffroid assisted in the writing of the report describing these costs and the associated benefits of keeping the US HCFC emissions below the Montreal Protocol Cap.

Updated Cold Storage End Uses Emissions Information, U.S. EPA (1999). Based on a review of the current inputs into the Vintaging Model and industry and literature information, Ms. Moffroid developed a model to troubleshoot current assumptions and determine more reliable estimations for accurate projections. In addition, Ms. Moffroid assisted in writing a memo detailing these problem areas and the proposed solutions.

Other Modeling Efforts

NYSERDA Lifecycle Cost Tool, NYSERDA (2001). Ms. Moffroid developed a model to estimate the economics of energy efficient lighting systems. These systems often pay for themselves through the significant energy, demand, and maintenance savings they provide. The model enables the user to input fixture comparisons for up to ten areas. Each area has an individual savings summary that you can print out. Additionally, the tool allows you to view and print out the total project savings for all areas.

EMPLOYMENT HISTORY

ICF International: Senior Associate, Associate, Analyst, Research Assistant	1999 – present
Spatial Informatics Group: Associate	2006 – present
University of Vermont: Graduate Research Assistant	2004 – 2006
Colgate University: Assistant to the Director	1998 – 1999
Colgate University: Grant for Independent Research-Stream Productivity Study	1998
Colgate University: Teacher's Assistant, Organic Chemistry	1998
Colgate University: Lab Technician	1996 – 1999

JESSICA KYLE **ICF INTERNATIONAL**

EDUCATION

M.S., Ecological Economics, Value, and Policy, Rensselaer Polytechnic Institute (RPI), Troy, NY [expected] 2009
Graduate coursework in Applied Economics, Johns Hopkins University, Washington, DC, 2006
B.A., International Politics and Economics, summa cum laude, Middlebury College, Middlebury, VT, 2003

EXPERIENCE OVERVIEW

Ms. Kyle, an Associate at ICF International, is an experienced researcher, data analyst, and writer on technical and economic analyses. She has over four years experience conducting analyses in the production sector for HCFCs and HFC alternatives, focused primarily on the refrigeration and AC sectors. Ms. Kyle has also conducted cost-benefit analyses related to the U.S. EPA SunWise Program, an appliance disposal program, methyl bromide phaseout, and the prohibition of carbon dioxide fire suppression systems in normally occupied spaces, served as a lead author on performance evaluations of the Multilateral Fund of the Montreal Protocol and the Global Environment Facility (GEF), including an analysis of the results of GEF ozone layer depletion, climate change, and POPs projects; and supported the U.S. EPA's Stratospheric Protection Division in its phaseout of HCFCs. Ms. Kyle also manages ICF's Task Order supporting SPD's efforts to phase out methyl bromide and provides day-to-day management of ICF's Task Orders supporting the SunWise Program. Ms. Kyle has also worked extensively with the U.S. EPA's Vintaging Model and Atmospheric and Health Effects Framework (AHEF) model for numerous analyses and is intimately familiar with its applications.

SELECT PROJECT EXPERIENCE

Analysis of Changes in HCFC Consumption and Emissions from the U.S. Proposed Adjustments for Accelerating the HCFC Phaseout, U.S. EPA (2007). For the U.S. EPA, Ms. Kyle supported an analysis of the potential reductions in HCFC consumption and emissions that would result from the adoption of the U.S. proposed adjustments for accelerating the HCFC phaseout. This quick turnaround analysis included assumptions in the Vintaging Model on the breakout of HCFCs in developed countries, the consumption to emissions ratio, and other assumptions.

Emission Reductions from Destruction of ODS Inventories, U.S. EPA (2006). For the U.S. EPA, Ms. Kyle estimated banks and stockpiles of ODS in the U.S. and worldwide, as well as estimated emission reductions resulting from destruction of those inventories. Accessible banks include those ODS contained in equipment in the fire protection (including halon 1211 in portables) and refrigeration/AC sectors. This analysis was based on the Vintaging Model.

Analysis of Economic Incentives for Reclaiming and Destroying ODS, U.S. EPA (2007). For the U.S. EPA, Ms. Kyle analyzed the economic impacts of a proposed program to provide monetary incentives for reclaiming and destroying recovered ODS and to assess fees on the sale of virgin ODS. This analysis involved using the Vintaging Model to estimate streams of virgin and reclaimed ODS and to calculate the total economic impact of the proposed program. As part of this analysis, Ms. Kyle estimated the incremental burden on the ultimate consumers of refrigerant (e.g., households who purchase/service residential AC systems, grocery stores who purchase/service retail food refrigeration systems). Ms. Kyle also considered whether the presence of a fee/subsidy program would change behavior—i.e., whether it enhances refrigerant management practices by increasing leak reduction and/or refrigerant recovery practices.

Estimated U.S. Health Effects Associated with Article 5 Parties Non-Compliance with the Montreal Protocol (2006). For the U.S. Environmental Protection Agency, Ms. Kyle estimate the incremental U.S. health effects estimated to result from non-compliance of Article 5 Parties with the Montreal Protocol for

years 2005 to 2030. Using the Vintaging Model, Ms. Kyle first calculated incremental emissions expected to result from non-compliance of Article 5 Parties with the Montreal Adjustment, and then estimated incremental U.S. health effects.

Estimated Costs Associated with U.S. Non-Compliance to the Montreal Protocol, U.S. EPA. For the U.S. Environmental Protection Agency, Ms. Kyle helped to draft preliminary estimates on the total costs to replace all new and existing ODS-containing refrigeration/air conditioning equipment in the U.S. with non-ODS-containing equipment from 2000 to 2020; and total monetary value of U.S. exports of ODS-containing refrigeration/air conditioning equipment between 2000 and 2020.

Analysis of Policy Options for an ODS Destruction Credit Trading Scheme, U.S. EPA (2006). For the U.S. EPA, Ms. Kyle analyzed several policy options for an ODS destruction credit trading scheme to increase the destruction of banked ODS that would otherwise be emitted to the atmosphere; some of the policy options also aimed to send market signals that essential and critical use exemptions under the Montreal Protocol will not be available ad infinitum. Ms. Kyle presented a number of considerations related to the design of an ODS destruction credit trading market, including those related to environmental benefits, the price of ODS, and the creation of positive incentives.

Cost of Accelerating the Phaseout of HCFCs in China, U.S. EPA (2007). For the U.S. EPA, Ms. Kyle conducted an analysis of the estimated incremental cost of accelerating the phaseout of HCFCs in China by 10 years HCFCs in China from 2030 to 2040 (i.e., by 10 years). Specifically, this analysis considered the incremental cost of: early retirement of HCFC equipment; transitioning HCFC production facilities and HCFC equipment production facilities to non-HCFC alternatives and equipment; and potential revenue foregone from CER credits associated with HFC-23 decomposition projects under the Clean Development Mechanism. The report also compared the analysis with a study performed by the German bilateral development agency, GtZ, on the incremental cost of the phaseout of HCFCs in China.

Economic Analysis of the SunWise Program, U.S. EPA (2003-Present). For the U.S. EPA, Ms. Kyle is conducting an economic analysis of the effectiveness of the SunWise Program, a national health and environmental education program designed to teach children in elementary and middle schools how to protect themselves from overexposure to the sun. Ms. Kyle is measuring the effectiveness of SunWise based on student responses to pre-test and post-test surveys regarding their sun protection practices. The work includes developing two ultra-violet (UV) radiation exposure models to estimate children's annual UV dose before and after participation in SunWise. The analysis employs the U.S. EPA's Atmospheric and Health Effects Framework (AHEF) model to translate reductions in cumulative UV exposure into avoided skin cancer incidence and mortality. The direct (medical) and indirect (productivity losses) costs avoided associated with preventing skin cancer were estimated and compared to the overall cost of implementing the program. Ms. Kyle also estimated the cost-effectiveness of SunWise by measuring life-years saved and adjusting those life-years to account for the reduced health-related quality of life associated with developing skin cancer. Ms. Kyle prepared a report for EPA on the methodology and results of the analysis and has presented the results to a panel of economic and scientific experts. Ms. Kyle is also the lead author on an article based on these results; this article has been accepted for publication in the American Medical Association's peer-reviewed journal Pediatrics.

Cost Assessment of Hypothetical Appliance Disposal Program, U.S. EPA (2006-2007). Ms. Kyle conducted a cost-benefit analysis of a hypothetical appliance disposal program. This work involved estimating potential avoided emissions of ozone depleting substances, greenhouse gases, and energy savings associated with proper handling and recycling/disposal of all components in domestic refrigerators/freezers, air conditioners, and dehumidifiers. Ms. Kyle also calculated human health impacts using the Atmospheric and Health Effects Framework (AHEF) model, and monetized these impacts to provide an overall estimate the social cost savings associated with the hypothetical program. This analysis contributed to the development of the Responsible Appliance Disposal (RAD) Program, which is a voluntary program for utilities, municipalities and manufacturers/retailers.

Estimating Halon 1301 Emissions from F-16 Aircraft and Resulting Health Impacts, U.S. EPA (2004). Ms. Kyle assisted in estimating the health effects associated with halon emissions from F-16 aircraft, including incremental health effects resulting from additional emissions from Operation Iraqi Freedom. Using this data, Ms. Kyle monetized the estimated increases in human health effects associated with increased halon emissions between 1991 and 2005, including incremental benefits calculated from incremental health effects associated with Operation Iraqi Freedom.

Cost-Benefit Analysis of a Proposed Prohibition on the New Installation of Carbon Dioxide Fire Suppression Systems in Normally Occupied Spaces, U.S. EPA (2005-2006). For the U.S. Environmental Protection Agency, Ms. Kyle analyzed the potential costs and benefits resulting from a prohibition on the new installation of carbon dioxide systems in normally occupied spaces. Specific tasks included determining the marginal cost of an average non-carbon dioxide system, deriving a relationship between carbon dioxide systems and rate of death or serious injury, assessing the overall economic impacts, and preparing a small business impact analysis. Ms. Kyle prepared a report on the methodology and results of the analysis.

Review of the Technical and Economic Availability of Feasible Alternatives to Recycled HCFCs in Existing Refrigeration Equipment, European Commission DG Environment (2005-2006). For the European Commission DG Environment, Ms. Kyle conducted a study to project the service demand for and supply of recycled and reclaimed HCFCs used in refrigeration and air conditioning equipment, and to assess the technical and economic availability of alternatives. Specifically, Ms. Kyle performed a cost analysis to determine the social cost associated with undue abandonment of equipment (i.e., equipment that is retired before the end of its useful lifetime as a result of the regulation). The final report of this study was submitted to the European Parliament and Council for consideration of whether to alter the current phaseout date for HCFC refrigerants.

SELECTED PUBLICATIONS AND PRESENTATIONS

Kyle JW, Hammitt JK, Lim HW, et al. Economic Evaluation of the U.S. Environmental Protection Agency's SunWise Program: Sun Protection Education for Young Children. Pediatrics (In press).

EMPLOYMENT HISTORY

ICF International: Associate, Analyst, Research Assistant	2003–present
The Wharton School, Business and Public Policy Department, University of Pennsylvania: Research Assistant	2002
Foreign Policy Research Institute: Editorial Assistant	2001

PANKAJ KUMAR **ICF INTERNATIONAL**

EDUCATION

M.C.P., Urban and Regional Planning, Massachusetts Institute of Technology, Cambridge, Massachusetts, 2005
M.S., Social Anthropology, University of Pune, Pune, India, 2003
B.S., Molecular Biology, Osmania University, Hyderabad, India, 2001

EXPERIENCE OVERVIEW

Pankaj Kumar is an associate with ICF International in the company's Energy and Resources Practice. He is an experienced researcher, data analyst, and writer on issues relating to ozone depletion and climate change. At ICF, he has worked on projects related to greenhouse gas emissions, the U.S. Environmental Protection Agency's stratospheric ozone program and significant new alternatives policy (SNAP) program for ozone depleting substance (ODS) alternatives. He worked on the development of an innovative ODS management project to obtain carbon credits for ODS destruction and currently supports work for the U.S. EPA regarding initiatives to promote the destruction of ODS in the U.S. and abroad.

SELECT PROJECT EXPERIENCE

Destruction of ODS for Carbon Credits, U.S. EPA (2006-Present). For the U.S. EPA, Mr. Kumar is supporting work to provide carbon credits to industries for the destruction of ODS—in lieu of indefinite storage or venting. The project was accepted for trading in the carbon markets as the world's first ODS project offset type in 2007 and companies can receive carbon credits for the destruction of their ODS. To this end, Mr. Kumar has helped develop a protocol document and an Excel-based calculation tool for determining and granting credits for ODS destruction. Additionally, in order to verify the destruction and removal efficiency (DRE) achieved during ODS destruction, Mr. Kumar coordinated research to determine the DRE achieved during the destruction of halons and/or HCFCs and is currently working with the research leads to get an academic paper published. Mr. Kumar has also briefly supported the development of estimates of the total U.S. bank of ODS that may be available for destruction in the future, demonstrating the strong need for a program to promote the destruction of this ODS.

Analysis of ODS Destruction in the U.S. and Abroad, U.S. EPA (2006-2007). For the U.S. EPA, Mr. Kumar supported the writing of the international regulations section of a report on the state of ODS destruction in the U.S., which will be released for public comment in the near future. This report contained (1) an extensive discussion of the relevant U.S. regulations affecting ODS, and more generally, hazardous waste destruction, including requirements under the Resource Conservation and Recovery Act (RCRA) and the Maximum Achievable Control Technology (MACT) standard for hazardous waste combustors; (2) a discussion of the emissions associated with the destruction of ODS and how these emissions might affect the capacity for ODS destruction in the U.S.; (3) a list of the known destruction facilities in the U.S. and the quantities of ODS destroyed in 2003 and 2004; (4) a discussion of the Montreal Protocol recommended criteria for the destruction of ODS and whether the U.S. facilities are and/or could meet these criteria; and (5) a summary of the costs for ODS transportation and destruction. Earlier version of this report also included a discussion of ODS destruction facilities abroad and the relevant regulations in several countries.

Methodology for Baseline Development and Measurement for an Ozone Depleting Substance Offset Project: Destruction of Ozone-Depleting Substances from Stockpiles or Equipment, U.S. EPA (2006). For the U.S. EPA, Mr. Kumar supported the finalization of a draft methodology for determining the ODS emissions offset by the destruction of ODS from either stockpiles or equipment as opposed to maintaining this ODS in the stockpiles/equipment. He helped undertake quality assurance for an analysis of the possible emissions sources associated with the various management scenarios for ODS at the end-of life

and conducted research and contacted several industry experts to compile information and data on the emissions of ODS associated with each management scenario, including emissions from equipment, storage, transfer, and destruction. She then prepared a report presenting the methodology and several examples of the emissions of potential ODS destruction projects as compared to the emissions of the baseline cases of continued storage or use in equipment, which would result in additional emissions of ODS. Mr. Kumar provided quality assurance for a Microsoft Excel-based tool to be used by companies to determine the potential emissions savings associated with an ODS destruction project as compared to a baseline case.

Voluntary Program for the Reduction of ODS Emissions, U.S. EPA (2006). For the U.S. EPA, Mr. Kumar has supported activities to help develop and, eventually, implement a voluntary program to reduce emissions of ODS, focusing on the destruction of ODS currently contained in equipment or stored in stockpiles. Specifically, Mr. Kumar has supported the preparation of briefs on program concepts; overarching issues that could affect the implementation and success of a program; potentially applicable sectors; ideas for participant achievement levels (e.g., a gold designation for companies that completely transition away from ODS use); partner benefits and responsibilities; EPA responsibilities including tools to provide; possible names; and examples of existing EPA voluntary partnerships.

U.S. Greenhouse Gas Inventory U.S. EPA (2006-Present). Mr. Kumar aids the ICF International lead in preparing the EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks by overseeing the Industrial Processes section of the Inventory, performing quality control measurements, coordinating database management, and managing the reporting. He recently provided the estimates of U.S. emissions in the common reporting format (CRF) required by the United Nations Framework Convention on Climate Change (UNFCCC).

EMPLOYMENT HISTORY

ICF International: Associate	2006-Present
Massachusetts Institute of Technology: Research Assistant	2003-2005
Kalpavriksh, Environment Action Group (India): Research Associate	2001-2003

SARAH MENASSIAN

ICF INTERNATIONAL

EDUCATION

B.S., Geological Sciences, Cornell University, Ithaca, New York, 2007

EXPERIENCE OVERVIEW

Ms. Menassian, a Research Assistant at ICF International, collaborates on projects involving ozone depleting substances, climate change indicators, greenhouse gas quantification, and support for the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*. Ms. Menassian is a recent graduate from the Engineering College at Cornell University where she gained experience working in a geochemistry clean laboratory analyzing atmospheric aerosols and using MATLAB to model volcano deformation.

SELECT PROJECT EXPERIENCE

Ozone Depletion

Collection and analysis of data on F-gas recovery in the EU-27 from 2004-2007, European Commission (2008-Present). For the European Commission, Ms. Menassian is working on a team that is analyzing recovery, reuse and destruction practices throughout the EU-27 from 2004-2007. Ms. Menassian is developing a set of questionnaires to be used in collecting data on F-gas recovery, reuse and destruction practices in industrial sectors covered by Article 4 of Regulation (EC) No 842/2006. After the surveys are disseminated in the coming months, Ms. Menassian will assist the team in reviewing responses and ultimately writing a report summarizing the results of the study.

Assessment of the phaseout date of HCFCs in the industrial process refrigeration sector and examination of infrastructure necessary to facilitate trade in recycled and reclaimed HCFCs after 2010, European Commission (2007-Present). Ms. Menassian is supporting the European Commission in conducting a study which aims to: (1) assess the availability and feasibility of alternatives to HCFC-based industrial process refrigeration (IPR) equipment, and (2) to investigate the measures in place in Member States to ensure that only recycled (not virgin) HCFCs are in use from 2010-2015 and to facilitate the trade of recycled HCFCs during that timeframe. Ms. Menassian is assisting in the development, dissemination and review of questionnaires sent to IPR equipment owners, reclamation facilities and Member State representatives. The data will be analyzed and aggregated to produce the final summary report.

Significant New Alternatives Policy (SNAP), U.S. EPA (2007-Present). Ms. Menassian supports the U.S. EPA's SNAP program in reviewing submissions for proposed ODS alternatives. Ms. Menassian assists in the initial review of a submission and upon the determination that a submission complete, Ms. Menassian assists in creating a risk screen for the substance. This involves modeling worst case exposure scenarios to ensure the alternative will not pose a threat to human health or the environment.

Ozone Depleting Substances Tracking System, U.S. EPA (2007-Present). Ms. Menassian is working on a team that is developing tools to track ozone depleting substances for the EPA. This project involves establishing QA/QC procedures to ensure the data is being collected uniformly and correctly and the development of Excel tools to track data.

SunWise Program, U.S. EPA, (2007-Present). Ms. Menassian is assisting in preparing updates to the SunWise Program's tool kit and has assisted EPA in recruiting new teachers to join the program.

Climate Change

Climate Change Indicators, U.S. EPA (2007-Present). Ms. Menassian is working with the team that is developing a set of climate change indicators for the U.S. EPA. This project involves researching

potential indicators of climate change by aggregating all data available on these indicators and creating a screening tool to be used in determining which indicators will be most useful.

Inventory of U.S. Greenhouse Gas Emissions and Sinks, Chapter on Agriculture, U.S. EPA (2007-Present). Ms. Menassian has been assisting ICF International's team working on the agriculture chapter of the Inventory by updating and performing QA/QC checks on the spreadsheets containing agricultural emissions data and the chapter text.

Inventory of U.S. Greenhouse Gas Emissions and Sinks, Layout, U.S. EPA (2007). Ms. Menassian assisted on the graphical layout of the Inventory by editing chapters and coordinating with the graphic designer.

LANGUAGES

French: fair in speaking, fair in writing

Spanish: fair speaking, fair in writing

EMPLOYMENT HISTORY

ICF International: Research Assistant	2007–Present
Cornell University: Student Research Assistant	2005–2007
Yale Peabody Museum: Museum Intern	Summer 2005

TRISTAN KESSLER

ICF INTERNATIONAL

EDUCATION

B.A., *magna cum laude*, Environmental Economics, Colgate University, Hamilton, NY, 2006

EXPERIENCE OVERVIEW

Tristan Kessler is a Research Assistant for ICF International in the company's Climate and Energy Policy division in the Energy and Resources practice. Since joining ICF, Mr. Kessler has been involved with multiple climate change projects in support of the U.S. EPA, including producing the annual U.S. Inventory of Greenhouse Gas Emissions and Sinks, developing emission estimates for EPA's Sector Strategies division, and creating a GreenScapes Food Waste Diversion Program Cost Calculator. Mr. Kessler also has modelling experience, serving on projects involving ICF's Vintaging Model for ozone-depleting substances (ODS) substitute emissions and the WAste Reduction Model (WARM) for municipal waste emissions. All of these projects have required a significant amount of data entry and documentation development, including adhering to a transparent methodology that clearly delineates model assumptions. His roles on these projects have also required significant modeling work, literature reviews, online research, industry contacts, and website development. Mr. Kessler graduated *magna cum laude* with a concentration in Environmental Economics and with distinction in the Liberal Arts Core Curriculum from Colgate University in 2006. His coursework included: applied econometrics, resource economics, environmental hazards, international economics including courses on the British economy and the European Economic Community, water resources, economic development, and ecology and evolution.

SELECT PROJECT EXPERIENCE

ICF's Vintaging Model to Estimate Emissions from ODS Substitutes, U.S. EPA (2007-Present). Mr. Kessler supports the continued development of ICF's Vintaging Model (VM) to track and project U.S. emissions from ODSs and their High-GWP substitutes. Mr. Kessler has performed research on the market structure and technical specifications of both ductless air conditioning systems and vending machines to evaluate their potential for inclusion into the VM. He is also involved with updating the mobile vehicle air conditioning end uses to reflect more recent data points and realistic assumptions. Mr. Kessler has become familiar with the model's extensive functions and output options through this work and other general model support. These functions include emissions from virgin manufacture, leakage, servicing, and disposal for the Refrigeration/Air Conditioning, Aerosols, Solvents, Fire Extinguishers, Sterilization, and Foams sectors.

Industry Profile of Production, Imports, and Exports of HFCs, PFCs, SF_6, and NF_3, U.S. EPA (2007). Mr. Kessler was involved in the development of a memorandum on U.S. production, imports, and exports of various fluorinated gases. Specifically, Mr. Kessler researched the imports of HFC bulk gas and pre-charged equipment. His work on this project included identifying and researching potential data sources, synthesizing gathered data, estimating upper and lower import bounds, and summarizing his research results in a transparent and effective manner.

Quantifying Greenhouse Emissions from Key Industrial Sectors in the U.S., U.S. EPA (2007). Mr. Kessler was involved with the production of a report on greenhouse gas (GHG) emissions from key industrial sectors for the EPA's Sector Strategies division. His work on this report included quantifying GHG emission estimates from fossil fuel combustion, non-combustion activities, and electricity purchases for the aluminum, lime, metal casting, mining, plastics and rubber products, semiconductors, and textile sectors. He also wrote descriptive text for the previous sectors that included a sector overview, sources of GHG emissions, estimation methodology, and trends over time.

U.S. Inventory of Greenhouse Gas Emissions, U.S. EPA (2007-Present). Mr. Kessler contributes to the annual development of the U.S. Greenhouse Gas Inventory. He is specifically involved with the Industrial Processes report, performing research in response to the UNFCCC Secretariat's inquiries concerning previous Inventory reports, as well as updating emission estimates for the Industrial Processes sectors. This updating work involves significant data entry, clearly delineating assumptions, and transparent documentation of sources and methodology. Mr. Kessler also compiles and maintains the docket of sources for the entire inventory and produces graphical figures for the report.

WAste Reduction Model (WARM), U.S. EPA (2007). Mr. Kessler was involved with updating the WARM, a publicly available model that helps organizations track and voluntarily report greenhouse gas emission reductions from several different waste management practices. His work on this project includes a literature review of existing scientific research and lifecycle analyses, as well as a proposal for both short- and long-term changes to enhance the scope of the model.

Food Waste Diversion Program Cost Calculator, U.S. EPA (2007). Mr. Kessler was responsible for developing an interactive computer model for the EPA's GreenScapes program that will determine the potential cost savings of various food waste diversion programs, based upon user input. His work on this calculator has included extensive research into the various potential costs associated with reducing, reusing, and recycling organic and non-organic food wastes. Mr. Kessler also works on model development, calculations, and coding.

National Environmental Performance Track Program, U.S. EPA (2007-Present). Mr. Kessler serves as a recruiter and provides general program support for the EPA's Performance Track program. As a recruiter, Mr. Kessler attends trade and government conferences across the country as an exhibitor. He also contacts company facilities to inform their management about the Performance Track program and to encourage them to apply. Mr. Kessler is involved with various other facets of the Performance Track program, including producing marketing and outreach materials, measuring and benchmarking the success of ICF's recruiting work, improving the program's web site, facilitating the production of two exhibition booths, producing and distributing member certificates, and other general program support as needed.

EMPLOYMENT HISTORY

ICF International: Research Assistant	2007–present
The Greenway Foundation: SPREE Team Member	2006–2007

STEFAN UNNASCH

LIFE CYCLE ASSOCIATES

EDUCATION

Bachelor of Science, Mechanical Engineering, University of California, Berkeley, 1983.

EXPERIENCE OVERVIEW

Stefan Unnasch is a Senior Partner at Life Cycle Associates. Mr. Unnasch supports the analysis of alternative energy options and ventures to examine the potential for carbon emission reductions. Mr. Unnasch has over 70 publications in the area of alternative fuels and has presented and lectured at technical conferences and universities around the world.

Between 1983 and 2007, Mr. Unnasch managed projects at Acurex and its successors through TIAX LLC related to the use of alternative fuels, in which he was responsible for the analysis of fuel production technologies, infrastructure, and fuel cycle energy and greenhouse gas impacts.

SELECT PROJECT EXPERIENCE

Lifecycle Analysis

Mr. Unnasch has performed fuel cycle analysis studies since 1987 were he developed analytical approaches that take into account the environmental constraints that apply to California. He develops models of well-to-wheel energy impacts and emissions including criteria pollutants, toxics, greenhouse gases, and global energy inputs. These analyses have included assessing the resource mix and transportation modes for fuel production, process modeling of fuel production plants, and vehicle drive cycle analysis. He has developed spreadsheet and database models that enable the calculation of regional specific emissions as part of a full fuel cycle analysis. His work on California fuel cycle analysis efforts includes serving as the Co-Chairman of the Societal Benefits Topic Team for the California Hydrogen Highway Blueprint Plan, support of California AB1007, and the Low Carbon Fuel Standard.

Mr. Unnasch was a participant in Annex XI, Lifecycle of Fuels, and Annex XV Fuel Cell Systems for Transportation under the International Energy Agency Operating Agreements. In this effort, he worked with a group of international experts on assessing the lifecycle emissions from conventional and alternative fuels. He also was the key U.S. contributor to Annex XV, Fuel Cell Systems for Transportation.

Alcohol Production

Mr. Unnasch led efforts to analyze the Costs and Benefits of a Biomass-to-Ethanol production Industry in California. He led teams that performed technical and economic analyses of ethanol production facilities that could be built in California, focusing on cellulosic conversion technologies covering a variety of feedstocks, including forest material, waste paper, rice straw, and urban waste. A macroeconomic evaluation considered potential costs to California and economic benefits from the ethanol industry as well as environmental benefits.

His work on lifecycle analysis includes many studies involving ethanol production pathways. He has examined the process conditions for starch and cellulose based pathways in order to determine date inputs needed for lifecycle analyses.

Over a four year period, Mr. Unnasch was the project manager for the Hynol biomass gasifier project. He led an engineering team through all of the steps in designing and constructing a 0.5 ton per day gasifier. Mr. Unnasch performed process analysis, cold flow modeling, P&ID development, safety reviews, controls interface design, vessel specification and procurement, and integration of the reactor vessels in a 30 ft structure. He developed control algorithms for the system P&ID, developed start up, safety, process

control, and data collection strategies. He oversaw or was directly involved in all project activities ranging from project development to pressure vessel inspection and facility installation.

Alternative Fuels

His work on alternative fuel development projects includes laboratory testing, process modeling, economic analysis, pilot plant design and construction, emission testing, and business strategy development. Mr. Unnasch developed equilibrium and kinetic based process models to support economic and life cycle analysis as well as technology development projects. He has worked on ethanol, hydrogen, fuel cell, methanol, CNG, LPG, GTL, and electric transportation technologies.

Fuel Cells

Mr. Unnasch was a key participant in several studies for private fuel cell and fuel cell component manufacturers that included the evaluation of fuel cell and reformer technologies. He evaluated the merits of fuel processor systems compared with state of the art data and assessed the manufacturing costs from several fuel cell component suppliers. Mr. Unnasch also supported a marketing plan for a fuel processor program that converted landfill gas to hydrogen.

He developed models to evaluate the fuel consumption and emissions from fuel-cell-powered vehicles which tracked flow streams, efficiency, and emissions for various fuel cell/vehicle battery combinations. The simulation model includes load-specific performance characteristics for fuel cells, turbo expanders, reformers, and other equipment. This analysis was also applied to a project to assess the performance of fuel cell cogeneration systems for buildings.

Project Development

Mr. Unnasch manages proposal efforts for alternative energy technology development and analysis projects. He develops bidding strategies, manages proposal teams and prepares proposals for state and Federal government agencies, energy companies, and non-governmental organizations. He led the development of several multi-million $ technology commercialization projects in the areas of biomass gasification, ethanol production, and hydrogen fuel cell systems. In this capacity Mr. Unnasch developed strategic alliances with technology partners, regulators, and government agencies.

SELECTED PUBLICATIONS

Perez, P., et al., "Evaluation of Biomass to Ethanol Fuel Potential in California," California Energy Commission Report in Response to Executive Order D-5-99, December 1999.

Unnasch, S., et al., "Societal Benefits Topic Team Report, California 2010 Hydrogen Highway Network," for Blueprint Plan March 2005.

Unnasch, S., S. Huey, and L. Browning, "Evaluation of Fuel Cycle Emissions on a Reactivity Basis," prepared for ARB under Contract A166-134, September 1996.

RICH PLEVIN

LIFE CYCLE ASSOCIATES

EDUCATION

Ph.D. in Energy and Resources, UC Berkeley [expected]
Masters of Energy and Resources, UC Berkeley, 2006
M.S., Computer Science, Yale University, 1982
B.S., *summa cum laude*, Computer Science and Applied Mathematics, SUNY Albany, 1981

EXPERIENCE OVERVIEW

Rich Plevin is a Senior Partner at Life Cycle Associates. Mr. Plevin supports the analysis of bioenergy options to examine the potential for carbon emission reductions, and manages the organization's software and model development. Between 2004 and 2007, as a consultant, Mr. Plevin developed several models and analyses of the lifecycle greenhouse gas impacts of proprietary ethanol production systems and waste-to-energy alternatives. From 1982 to 2004, as a software engineer and systems architect, Mr. Plevin developed systems for a range of clients in the financial services, biotechnology, digital media, and software industries.

SELECT PROJECT EXPERIENCE

Lifecycle Analysis

Mr. Plevin has developed energy and greenhouse gas studies of ethanol production systems for fuel producers, regulators (in the UK), and for scientific publications. His masters paper at UC Berkeley focused on the differential climate impacts of biofuel production systems, and the uncertainties therein.

Mr. Plevin was a member of the UC Berkeley study team preparing a report on the state's Low Carbon Fuel Standard for the California Air Resources Board. He co-authored the sections of the report dealing with biofuels, lifecycle analysis, uncertainty, and compliance. He also served as peer reviewer for the biofuels sections of the AB 1007 Full Fuel Cycle Analysis study.

Richard co-developed the ERG Biofuel Analysis Meta-Model (EBAMM) to compare six bioethanol energy analyses to understand the divergence in published results. He lead the model design and implementation effort, and contributed significantly to the highly-cited paper published in Science, January 2006, as well as the extensive Supporting Online Materials.

Mr. Plevin is a co-author of Life Cycle Associates' BEACCON (Biofuels Emissions and Cost Connection) model, which estimates lifecycle emissions, energy, and cost for corn ethanol production.

Energy Systems Modeling and Software Support

Richard has developed a range of software and spreadsheet models of energy systems and biofuel production, including an optimization model of switchgrass production and a re-implementation of an optimization model of the global transition to synfuels. He has developed tools to automate and document the modification of complex spreadsheet models such as GREET and LEM, and is currently developing a custom language to specify and compute the lifecycle impacts of specific fuel production pathways.

Sustainability Analysis

Mr. Plevin has co-authored two policy-oriented studies on alternative energy systems, including a paper on creating markets for "green" biofuels through measurement of lifecycle climate and sustainability impacts. He co-authored and managed the development of a report for the Santa Barbara Community

Environmental Council on the in-state resources, technologies, economics, and environmental attributes of bioenergy conversion technologies.

SELECTED PUBLICATIONS

Plevin, R.J. and Mueller, S. "Producing Ethanol for Low-Carbon Fuel Markets", Ethanol Producer Magazine, May 2007.

Turner, B.T., Plevin, R.J., O'Hare, M., and Farrell, A.E.. "Creating Markets for Green Biofuels: Measuring and improving environmental performance." Research Report, Transportation Sustainability Research Center, University of California, April 2007.

M. Chester, R. Plevin, D. Rajagopal, and D. Kammen. "Biopower and Waste Conversion Technologies for Santa Barbara County, California", Report for the Santa Barbara Community Environmental Council, Feb. 2007.

Farrell, A.E., Plevin, R.J., Turner, B.T., O'Hare, M., Jones, A.D., Kammen, Daniel M., Ethanol Can Contribute to Energy and Environmental Goals, Science, Jan. 27, 2006.

BRENT RIFFEL

EDUCATION

M.S. Transportation Technology and Policy, Institute of Transportation Studies, UC Davis [expected]
B.A., Chemistry, Pomona College, 2003

EXPERIENCE OVERVIEW

Brent Riffel is an Engineer at Life Cycle Associates. Mr. Riffel conducts lifecycle emissions and energy analyses and cost estimation for conventional and alternative fuel pathways. He is experienced with developing LCA tools and providing support for public policy making. From 2004 to 2007, Mr. Riffel pursued a Masters degree (currently pending) at the Institute of Transportation Studies at UC Davis where he conducted extensive lifecycle analysis of hydrogen and alternative fuel pathways and developed the model framework to estimate the CO_2-equivalence factor for NO_x emissions. Between 2005 and 2007, Mr. Riffel worked in the Sustainable Transportation branch at the California Air Resources Board providing support to the Hydrogen Highway Initiative and developing a GIS database of CA hydrogen activities. Mr. Riffel also worked as an Atmospheric Scientist at NASA Ames Research Center between 2003 and 2004, where he independently designed and executed atmospheric research concerning NO_x cycling.

SELECT PROJECT EXPERIENCE

Lifecycle Analysis

Mr. Riffel has conducted lifecycle analysis since 2003 using the GREET and LEM models. He has performed numerous scenario analyses and examined the uncertainty and sensitivity of model results. Brent has provided results to numerous organizations, including UC Davis, California Air Resources Board, CEC and Argonne National Lab. He is extremely familiar with both models and has expanded the LEM and built custom analytical tools using components from GREET. Brent is also a co-author of the BEACCON (Biofuels Emissions and Cost Connection) model, which estimates lifecycle emissions, energy and cost for corn ethanol production.

Public Policy Analysis

Mr. Riffel has participated in the review and discussion process for several California greenhouse gas initiatives throughout his time at CARB. He helped review the AB-1007 analysis, provided input for the Hydrogen Highway environmental standards (SB-1505) and participated in several working group forums for the Low Carbon Fuel Standard in California. Brent also helped ARB assess the success and "accessibility" of the existing hydrogen network in California and analyze the best places for future expansion.

SELECTED PUBLICATIONS

Riffel, B., et al.; "The Acid Catalyzed Nitration of Methanol: Formation of Methyl Nitrate via Aerosol Chemistry," Journal of Atmospheric Chemistry, draft submitted and accepted, 2007.

Riffel, B., "Estimating the Carbon Dioxide Equivalency Factor (CEF) Associated with Emissions of Nitrogen Oxides," ITS publication, submitted and pending review, 2007.

ROBERT EWING **SVD-SCC, INC.**

EDUCATION

M.B.A., Santa Clara University, Santa Clara, CA
B.S., Economics; University of Florida, Gainesville

EXPERIENCE OVERVIEW

Robert Ewing is the owner and founder of SDV-SCC, Inc., a Disabled Veteran Business Enterprise (DVBE) and Small Business Enterprise (SBE), Certified by the Office of Small Business and DVBE Services, Department of General Services, State of California. SDV-SCC, Inc. provides professional services to a spectrum of clients, focusing on federal government agencies, California state agencies, commissions and departments, and prime contractors. Mr. Ewing is a senior operations/administration executive with demonstrated successes in both Fortune 500 and "Big 4" environments, complemented with hands-on experience in complex startup and turnaround situations; built on a solid foundation of financial management, organizational development, and systems planning and implementation.

SELECT PROJECT EXPERIENCE

Manufacturing, Fiskars Electronics. Significantly enhanced bottom line profitability of a $20 million mid-technology manufacturing operation by directing a highly efficient and complex downsizing, plant closure, and key personnel relocation effort impacting five corporate locations nationally.

Health Care, National Health Enterprises. Led a critical and cost effective turnaround for a group of 20 health care facilities resulting in a net recovery of over $1 million in bad debt, reduction in overall operating losses of $2.4 million, returning the region to profitable operation.

Public Accounting, Arthur Andersen & Co. Introduced new PC operating and capital budgeting system to a group of 10 partners with total budgetary responsibility of $10 million. This radical new system not only standardized reporting essential to senior management, but substantially reduced attendant time and costs.

Fortune 500, Crown Zellerbach. Developed and implemented management development program to break a middle management succession bottleneck, reducing recruitment and training costs by $500,000.

Entrepreneurship, Alphagraphics. Initiated and led the planning, startup, development and subsequently the successful divestiture of a high technology commercial graphics and printing operation.

Interim Chief Financial Officer and Facility Security Officer, Charles Evans & Associates. For one year, complete financial reporting, internal controls, cash management, payroll and banking responsibility for this $20 million scientific analysis laboratory and government contractor. U.S. government contracts with DOE, National Science Foundation, and DoD DARPA (classified), including audits by Defense Contract Audit Agency (DCAA). Top Secret security clearance.

Interim Chief Financial Officer, Atlas International Meetings and Events. Complete financial accounting and reporting responsibilities, including bank relations, budgeting and operational business planning. Created budget model and related training for event managers.

U.S. Navy, Lieutenant - Administrative and Personnel Officer, Naval Flight Officer. Two cruises to Southeast Asia with Fighter Squadron 96, USS Enterprise; 168 combat missions North Viet Nam as Radar Intercept Officer, F-4 Phantom crewmember, 230 carrier landings. Eleven Air Medals, Navy Commendation Medal, Navy Unit Citation. U.S. Army Airborne parachute jump wings.

PROFESSIONAL AFFILIATIONS

American Staffing Association, National Contract Management Association

EMPLOYMENT HISTORY

SDV-SCC, Inc.: Owner and Founder	
Charles Evans & Associates: Interim Chief Financial Officer and Facility Security Officer	
Atlas International Meetings and Events: Interim Chief Financial Officer	
Graduate School of Business, Santa Clara University: Lecturer in Accounting	5 years
Auburn University: Assistant Professor of Naval Science	2 years
U.S. Navy, Lieutenant: Administrative and Personnel Officer, Naval Flight Officer	
American Kennel Club, Canadian Kennel Club, and the American Herding Breed Association: Licensed Performance Judge (Herding)	
U.S. Coast Guard: Licensed Master (Captain), 25 Ton Vessels	

EXHIBIT B
Standard Agreement

BUDGET DETAIL AND PAYMENT PROVISIONS

1. **Invoicing and Payment**

   A. For services satisfactorily rendered, and upon receipt and approval of the invoices, the State agrees to compensate the Contractor for actual expenditures incurred in accordance with the rates specified herein, which is attached hereto and made a part of this Agreement.

   B. Invoices shall include the Agreement Number and shall be submitted in triplicate not more frequently than ~~quarterly~~ monthly in arrears to:

   Air Resources Board
   Research Division
   P.O. Box 2815
   Sacramento, CA 95812-1436
   Attn: Emma Plasencia

   C. Contractor, upon written approval by the State's Project Representative, may rebudget funds for a cumulative total of ten (10) percent or $25,000 whichever is less, between the major budget categories listed in Exhibit B.

   D. Upon mutual agreement, State will give consideration to re-budgeting requests, however; no re-budgeting in excess of ten (10) percent and no re-budgeting of funds into the travel category may be performed without Research Division Chief's written approval. The total agreement cost will remain unchanged.

2. **Budget Contingency Clause**

   A. It is mutually agreed that if the Budget Act of the current year and/or any subsequent years covered under this Agreement does not appropriate sufficient funds for the program, this Agreement shall be of no further force and effect. In this event, the State shall have no liability to pay any funds whatsoever to Contractor or to furnish any other considerations under this Agreement and Contractor shall not be obligated to perform any provisions of this Agreement.

   B. If funding for any fiscal year is reduced or deleted by the Budget Act for purposes of this program, the State shall have the option to either cancel this Agreement with no liability occurring to the State, or offer an agreement amendment to Contractor to reflect the reduced amount.

3. **Prompt Payment Clause**

   Payment will be made in accordance with, and within the time specified in, Government Code Chapter 4.5, commencing with Section 927.

EXHIBIT B
Standard Agreement

INITIAL HERE

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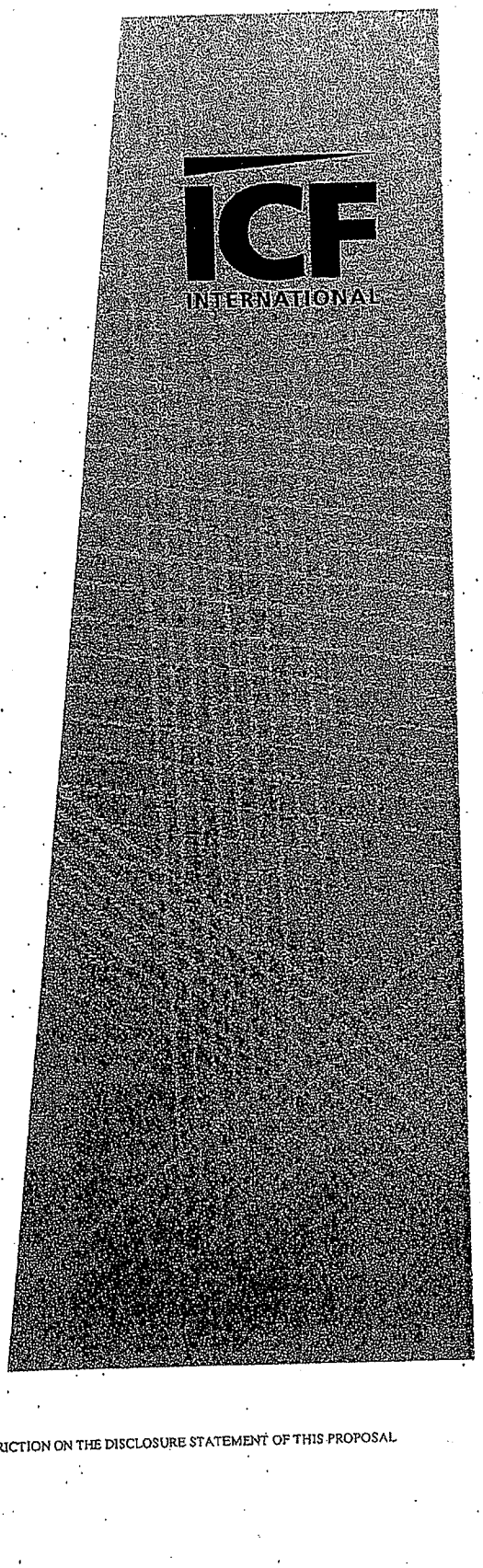
ICF INTERNATIONAL

Lifecycle Analysis of High-Global Warming Potential Greenhouse Gas Destruction



Financial Proposal

February 13, 2008

Prepared for:

Air Resources Board
Contract Services Section
1001 I Street, 20th Floor
Sacramento, CA 95814

ORIGINAL

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ICF INTERNATIONAL

February 14, 2008

Sharon Simmons
Air Resources Board
Contract Services Section
1001 I Street, 20th Floor
Sacramento, CA 95814
Ref: RFP Number 07-330

Dear Ms. Simmons,

ICF Consulting Services, LLC (an ICF International company) is pleased to submit this response to Request for Proposal (RFP) Number 07-330, **Lifecycle Analysis of High-Global Warming Potential Greenhouse Gas Destruction**. The ICF Team, which includes two subcontractors Life Cycle Associates, and SDV-SCC, comprises highly experienced individuals that offer significant expertise in performing lifecycle analyses and in end-of-life options for high-global warming potential (high-GWP) greenhouse gas (GHG). We are confident that our history of quality services in the high-global warming potential GHG industry for national and state entities, as well as private corporations, offer the California Air Resources Board superb capabilities for the requested services.

The ICF Team includes the following partners:

- **ICF Consulting Services, L.L.C.**—a leading US-based policy and research consulting firm with experience in lifecycle analyses, recovery and destruction options for all of the high-GWP sectors, and preparing detailed assessments of high-GWP GHG emission scenarios.
- **Life Cycle Associates**—specializes in analyzing emissions and energy use on a complete lifecycle basis. They are experienced creating analyses for fuel cycles, processes, economics, and GHG strategies.
- **SDV-SCC, Inc.**, a Disabled Veteran Business Enterprise (DVBE) and Small Business Enterprise (SBE), with experience in lifecycle assessment and expertise in organization and financial management, organization development, and systems planning and implementation.

The attached Financial Proposal describes our cost assessments for this project. Our proposal includes signatures on required enclosures by me, Laurence M. Rose, in the capacity of authorized binding official. We look forward to the opportunity to work with ARB. Please feel free to contact Mark Wagner, Project Manager, at 202-862-1155, should you have any questions or require additional information. For contractual inquiries, please contact Nakia Adams, Contracts Manager, at 703-934-3646 or ndams@icfi.com.

Sincerely,

Laurence Rose
Vice President, Director of Contracts
703-934-3557
LRose@icfi.com

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Basis of Estimate

1.1 Direct Labor Rates

ICF Consulting Services, L.L.C. (ICF), has proposed hourly rates based on actual labor rate information dated January 28, 2008. These rates were current at the time of proposal preparation.

1.2 Allocation of Hours

The estimated hours by task are for 12 months. ICFs estimate is based on our experience in performing similar work for other clients, and reflects the results of our detailed analysis of the different activities to be performed under each task and the total estimated number of deliverables (including drafts and final versions) that will be required. Our distribution of hours across the labor categories also reflects the staffing mix that ICF believes will be most cost-effective in completing this work.

1.3 Allocation of Other Direct Costs (ODCs)

It is ICF's disclosed accounting practice to recover contract specific other direct costs as a direct charge to any specific contract. Such other direct cost elements include but are not limited to courier/messenger, computer related, material/supplies, postage/express mail, printing, reproduction, telephone and travel.

1.4 Period of Performance

The proposed period of performance is:

Base Year – June 27, 2008 through June 26, 2009

ICF's proposal will remain in effect for a period of a hundred twenty (120) days from the date of submission, which is February 14, 2008. ICF retains the right to review its submission and to extend its offer or to revise its proposal based on the facts known to us at the end of the hundred-twenty-day period.

1.5 Cost Justifications

The staff selected for this project have extensive experience related to the high-GWP gases under investigation in this project. The level of effort (LOE) indicated for each staff member has been carefully considered to provide CARB with cost-effective services. Junior staff members will provide research and other project support, while ICF's sector experts will oversee the research efforts, contributing their sector knowledge and ensuring a high quality project. The rates proposed for each staff member are competitive with the environmental consulting industry overall.

Additional Information

- DUNS Number – 06-524-6527
- CAGE Code – 3AV32
- Federal Tax Identification Number – 04-3647360
- Size Status – Large Business

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- ICF has prepared this submission based on a Firm Fixed price contract
- Invoices will be submitted based on the milestones indicated in Table 1

Table 1: Schedule of Payment

Milestone	% of award
Kick-Off Meeting (Task 0)	20%
Literature Review Summary (Task 1)	10%
Refined Research Plan (Task 2)	10%
Data Analysis Report (Task 3)	20%
Draft Report (Task 4)	20%
Final Report (Task 4)	10%
Technical Seminar (Task 5)	10%

Remittance Address

Our electronic funds transfer address is:

Account Name: ICF Consulting Group, Inc.
Fairfax, Virginia

Bank: Citizens Bank
1 Citizens Drive
Riverside, RI 02915

ABA Number: 036076150

Account Name: ICF Consulting Group, Inc.

Account Number: 6203219502

or

Lockbox Address:

ICF Consulting Services, L.L.C.
P.O. Box 7777 – W510501
Philadelphia, PA 19175-0501

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Budget Submittal Form

This form is supplied for presenting budget detail to the Air Resources Board.

PLEASE TYPE OR PRINT:

Title of Proposal:	**Lifecycle Analysis of High-Global warming Potential Greenhouse Gas Destruction RFP No. 07-330**
Total Budget Requested:	**$ 297,765**
Period Covered (months):	**12**
Business or Institution:	**ICF Consulting Services, L.L.C.**
Address:	**9300 Lee Highway, Fairfax, VA 22031**

Name of person authorized to bind this bid: Laurence M. Rose

Title: **Vice President, Director of Contracts** **Phone:** **(703) 934-3557**

Signature of person authorized to bind this bid: Laurence M. Rose

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Budget Summary

Direct Costs

1.	Labor & Employee Fringe Benefits	$ 100,379.74
2.	Subcontractor(s)/Consultant(s)	$ 77,638.00
3.	Equipment	$ -
4.	Travel & Subsistence	$ 420.50
5.	Electronic Data Processing	$ -
6.	Photocopying & Printing	$ 330.00
7.	Mail, Telephone, and FAX	$ 350.82
8.	Materials & Supplies	$ -
9.	Analyses	$ -
10.	Miscellaneous	$ -
	Total Direct Cost	$ **179,119**

Indirect Costs

11.	Overhead	$ 63,076.34
12.	General & Administrative Expenses	$ 28,499.68
13.	Other Indirect Costs	$ -
14.	Fee or Profit	$ 27,069.51
	Total Indirect Cost	$ **118,646**

Total Direct and Indirect Cost: $ **297,765**

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Budget Detail

A. Direct Costs

1a. Labor Charges

	Last Name	First Name	Work Title	Est. Hours	Rate/Hour	Cost
A.	Wagner	Mark C	Executive	108	$76.89	$8,303.83
B.	Rotherham	Duncan G	Project Manager	35	$71.22	$2,492.54
C.	Lanza	Robert V	Project Manager	111	$57.25	$6,354.28
D.	Mathis	Pamela E	Project Manager	165	$45.72	$7,543.65
E.	Van Pelt	Marian M	Project Manager	126	$54.81	$6,906.49
F.	Groth II	Philip H	Senior Associate	108	$37.11	$4,007.56
G.	Kyle	Jessica Warren	Senior Associate	78	$34.34	$2,678.34
H.	Facanha	Cristiano	Senior Associate	65	$45.26	$2,941.90
I.	Li	Sandy	Associate	24	$30.93	$742.26
G.	Menassian	Sarah J	Research Assistant	430	$21.89	$9,414.83
K.	Cohen	Jonathan P	Project Manager	60	$69.62	$4,177.36
L.	Moffroid	Katrin M	Senior Associate	230	$40.30	$9,269.00
M.	Russell	Robert J	Senior Associate	39	$103.33	$4,030.00
N.	Kumar	Pankaj	Associate	58	$28.66	$1,662.55
O.	Kessler	Tristan	Research Assistant	310	$21.89	$6,787.43
				1,947.00		

Subtotal:	$77,312

The staff selected for this project has extensive experience related to the high-GWP gases under investigation in this project. The level of effort (LOE) indicated for each staff member has been carefully considered to provide CARB with cost-effective services. Junior staff members will provide research and other project support, while ICF's sector experts will oversee the research efforts, contributing their sector knowledge and ensuring a high quality project. The rates proposed for each staff member are competitive with the environmental consulting industry overall.

Mark Wagner will serve as the Engagement Leader and will be responsible for overseeing all tasks and ensuring that work is performed to the highest quality and delivered on time and within budget. Mr. Wagner is an ICF Senior Vice President with 25 years of experience in the fields of technical, economic, and regulatory analysis for the US Environmental Protection Agency, the European Commission, the World Bank, the United Nations Environment Programme, the Australian Greenhouse Office, the Global Environment Facility, and the US

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

Food and Drug Administration. For these initiatives, he provides technical and managerial oversight in the areas of risk assessment and toxicity screening for chemicals, emission projections; health effects and atmospheric modeling; regulatory, technical, economic, and cost/benefit analyses; and market characterizations to support rulemaking activities. He will be the primary point of contact for CARB, will ensure team integration and quality control, and facilitate access to corporate resources, as needed.

Pamela Mathis will serve as a project manager. Ms. Mathis, a Project Manager at ICF International, works on economic and scientific issues related to international stratospheric ozone depletion and global climate change. She is experienced in developing emissions inventories and evaluating technology options to mitigate those emissions. She is also experienced in developing and disseminating surveys, collecting and analyzing data, writing technical and scientific documents, building and running models, conducting research and evaluations, and writing communications and outreach pieces. She has played leading roles in the development and maintenance of the refrigeration/AC and fire sectors of the U.S. Environmental Protection Agency's (U.S. EPA's) Vintaging Model to inventory ODS and high-GWP gases in the United States, as well as analyses for both domestic and international marginal abatement curves (MACs) for non-CO2 high-GWP gases, including those developed for the California Energy Commission (CEC), the U.S. EPA, the Australian Greenhouse Office (AGO), and the International Energy Agency (IEA). Ms. Mathis has also developed and disseminated over a dozen surveys to industry and government representatives related to the development of ODS/high GWP emission inventories and abatement options. She has also conducted countless other analyses related to the refrigeration/AC and fire protection sectors for clients worldwide, including the European Commission (EC), the World Bank, the Global Environment Facility (GEF), and the U.S. EPA. This work has included the preparation of market characterizations, substitutes assessments, emission projections, as well as cost-/benefit and small business analyses related to the development and implementation of regulations to minimize emissions of ODS and their substitutes. As project manager, Ms. Mathis will manage the sector experts and will supervise the research and drafting of the final report.

Marian Van Pelt, a Principal at ICF International, has 14 years of experience conducting research, performing environmental analyses, supporting national policy, and developing models related to climate change and stratospheric ozone depletion. She has provided technical support to the US EPA in the areas of emissions modeling, developing emission estimates for the US GHG inventory, tracking emissions of ozone-depleting chemicals, and developing marginal abatement cost curves. Since 1999, Ms. Van Pelt has been the lead coordinator in support of the development of EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks, responsible for generating emission estimates from numerous industrial sources, in addition to aggregating all the data and creating the final Inventory document.

Duncan Rotherham will serve as a technical expert for this analysis. Mr. Rotherham is a Principal with ICF International working in the Energy Group's Energy Markets Practice. He has 10 years experience providing a wide range of services to the North American and International oil and gas, electricity/gas utility, aluminum and metals, forest products, manufacturing, and chemical sectors. Mr. Rotherham has supported DuPont since 1999 in their high GWP abatement projects in the areas of N_2O from Adipic and Nitric Acid facilities and HFC-23 from HCFC-22 production facilities. Internationally, he has supported the development of Project Design Documents for the

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Adipic (2) and Nitric N_2O (3) abatement project developers in the Clean Development Mechanism and Joint Implementation. All these projects required a detailed understanding of the production process, data management and abatement technologies. Mr. Rotherham has worked with over 40 companies to assess current emissions management systems, identify gaps, develop robust inventories, implement transparent operating procedures, and tools. Mr. Rotherham has also assessed emission abatement options, developed coordinated multi-pollutant emission reduction strategies, supported the development of marginal abatement cost curves (MACs), and quantified carbon risk. Mr. Rotherham will provide expert input in developing the detailed research plan and overseeing the data analysis.

Cristiano Facanha, PhD will serve as an expert on the process of lifecycle assessment. Dr. Facanha is a transportation engineer with 10 years of experience in the transportation industry. During his Ph.D. program at the University of California at Berkeley, Dr. Facanha completed a life-cycle assessment (LCA) of transportation systems. His research concentrated on both process-based LCA and economic input-output analysis-based LCA to evaluate and quantify the environmental effects of vehicles, transportation infrastructure, and fuels. He has experience with many LCA tools, such as GREET, Gabi, and EIO-LCA. Dr. Facanha recently assisted in the review process of the TIAX's Well-to-Wheels report to the California Energy Commission, which evaluated the greenhouse gas emissions from several vehicle technologies and fuels. His current work at ICF also involves the development of operational and technological strategies to prevent and mitigate environmental impacts of freight transportation.

Jonathan Cohen, PhD will serve as the senior statistician. Dr. Cohen has 25 years of experience in the field of statistical theory and its applications to the statistical data analysis of environmental land, air, and water quality and emissions data. He uses these skills in the design and analysis of experiments and sample surveys, general linear models, database management, applied probability, and statistical simulation. He has designed and performed analyses of surveys of (1) daily activity patterns for Californians used in an indoor air exposure model, (2) human activity patterns and simulated exertion rates derived from the National Human Activity Pattern Survey, (3) public awareness and response to the "Spare the Air" program, and (4) populations and activity patterns for selected emissions source categories in Maricopa County and Texas nonattainment areas.

Mr. Robert Lanza, P.E. will serve as a technical specialist and will be responsible for leading the incineration and destruction analyses. Mr. Lanza is a Principal Chemical Engineer with more than 25 years of experience in conducting environmental assessments of private sector and government facilities; providing regulatory development and environmental program management support to Federal agencies, and providing assistance in preparing technical analyses and carbon storage and emission calculations for the Inventory of U.S. Greenhouse Gas Emissions and Sinks for the EPA. Mr. Lanza is Lead Author of the Intergovernmental Panel on Climate Change (IPCC) 2006 Greenhouse Gas Inventory Guidelines (2006 GL) for Petrochemical and Carbon Black Production and a Contributing Author to the 2006 GL for Iron and Steel and Metallurgical Coke Production. Mr. Lanza is also providing technical support to EPA for assessment of ozone-depleting substance destruction and for lifecycle analysis of packaging materials. Mr. Lanza is providing engineering support to GreenBlue's efforts to obtain industry-specific lifecycle data on 17 material types including seven plastics, various paper types, glass, aluminum, and steel in order to update and expand the

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MERGE tool (Managing Environmental Resources, Guidance and Evaluation) for analysis of the greenhouse gas, energy, and resource intensity impacts of various types of packaging materials, and is also providing similar support to the U.S. EPA Climate and Waste Program in developing in developing Greenhouse Gas emission factors for packaging materials. Mr. Lanza recently conducted site visits to solvent recovery and appliance recycling facilities in England and Germany as part of a study of the collection and destruction of unwanted ODS in appliances and bulk ODS being conducted by ICF for the Multilateral Fund Secretariat and United Nations Environment Program (UNEP).

Robert Russell is ICF's foam sector expert and will provide input for the development of methodologies and the analysis of this sector. He has over 20 years of technical and regulatory experience in insulation foams and serves as a member of UNEP's Foams Technical Options Committee. Previously, Mr. Russell was a Technical Director for Dow Chemical in the insulations foams business. His knowledge transcends across several insulation foam categories such as XPS (Extruded Polystyrene), PUR (Polyurethane) and PIR (Polyisocyanuarate) foam products. In addition, he has worked in the area of ozone-depleting substances (ODS) and GWP-reducing substitutes across many product sectors, including foams. Mr. Russell has conducted past LCCP studies on foams used in residential and commercial building construction applications across blowing agents similar to those being analyzed in this study. He is also knowledgeable of the value of LCCP analysis results in highlighting the benefits of foam insulation products and their corresponding blowing agents to regulators and the International Community. Mr.Russell has worked on several projects supporting the U.S. EPA's Global Programs division on projects involving ODS and GHG analyses.

Philip Groth will serve as ICF's programming expert. Mr. Groth serves as the lead programmer of EPA's Vintaging Model, a model that characterizes emissions of ozone-depleting substances (ODS) and their substitutes. Mr. Groth also has experience with mitigation analyses of a wide array of high-GWP sources.

Katrin Moffroid is a Senior Associate at ICF International with over 8 years of consulting experience providing climate change and stratospheric ozone related technical and policy support to the U.S. Environmental Protection Agency (EPA), state governments, the Australian Greenhouse Office, the New Zealand Ministry for the Environment, European Commission, and other organizations. She has provided assistance in preparing national and state-level inventories and modeling both emission and reduction opportunities for greenhouse gases. Ms. Moffroid has extensive modeling expertise for both emission inventories and mitigation options of high-GWP gases within the ODS substitute sectors, including for publications such as the *U.S. Inventory of US Greenhouse Gas Emissions and Sinks* and *Global Mitigation of Non-CO_2 Greenhouse Gases.* In addition, Ms. Moffroid was the lead model developer for a tool to estimate GHG abatement options for the government of New Zealand.

Jessica Kyle will oversee the literature review and provide sector expertise. Ms. Kyle is experienced at conducting analyses on production, consumption, and emissions of ODS substances and their High-GWP substitutes. Ms. Kyle has developed estimates of ODS stockpiles and banks by sector in the United States and worldwide, as well as estimated emission reductions resulting from destruction of those inventories and has also estimated ODS inventories by end use for the European Commission DG Environment. In addition, Ms. Kyle has extensive experience developing surveys and providing logistical support for their dissemination and collection. Ms. Kyle will manage junior staff

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in assisting in the literature review and will oversee the development of a summary report for the review.

Pankaj Kumar is an associate with ICF International in the company's Energy and Resources Practice. Mr. Kumar is an experienced researcher, data analyst, and writer on economic, scientific, and policy issues related to ODS destruction. He supported the preparation of several reports and memorandums for the U.S. EPA's significant new alternatives policy (SNAP) program for ODS alternatives. Recently Mr. Kumar has worked on designing an offset project protocol for the U.S. EPA to determine greenhouse gas (GHG) emissions saved by the destruction of ozone depleting substances (ODS) at end-of-life; the protocol was adopted by the Chicago Climate Exchange (CCX) as the world's first and only non-Kyoto GHG offset project type.

Sarah Menassian will provide support for all tasks on this project. Ms. Menassian has experience conducting analyses on recovery, reuse and destruction practices for high-GWP ozone depleting substances in the EU-27 for the European Commission. In conducting such analyses, Ms. Menassian has gained experience in developing, disseminating and collecting surveys. She also works with the U.S. EPA to track the production, import, export, destruction and transformation of ODS for domestic regulatory purposes.

Tristan Kessler will provide support for the literature review, data analysis and report writing of this project. Mr. Kessler has experience modeling the production, consumption, and emissions of ODS substances and their High-GWP substitutes through ICF's Vintaging Model. He participated in an analysis on the imports, exports, and domestic production of HFCs, PFCs, SF_6, and NF_3 for U.S. EPA, specifically researching the imports of HFCs into the U.S. He is familiar with high-GWP emissions from industry, having worked on the Industrial Processes chapter of the U.S. Inventory, as well as a Sector Strategies report for U.S. EPA that included an estimation and discussion of emissions from the aluminum and semiconductor industries. Mr. Kessler is also an experienced researcher, having performed research tasks and literature reviews for a variety of projects, including a literature review of recent life cycle analyses on waste management strategies.

1b. Fringe Benefits

	Individual's Name		BASE ($)	RATE (%)	COST
A.	Wagner	Mark C	8,304	34.00%	2,823
B.	Rotherham	Duncan G	2,493	34.00%	847
C.	Lanza	Robert V	6,354	34.00%	2,160
D.	Mathis	Pamela E	7,544	34.00%	2,565
E.	Van Pelt	Marian M	6,906	34.00%	2,348
F.	Groth II	Philip H	4,008	34.00%	1,363
G.	Kyle	Jessica Warren	2,678	34.00%	911
H.	Facanha	Cristiano	2,942	34.00%	1,000

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I.	Li	Sandy	742	34.00%	252
G.	Menassian	Sarah J	9,415	34.00%	3,201
K.	Cohen	Jonathan P	4,177	34.00%	1,420
L.	Moffroid	Katrin M	9,269	9.80%	908
M.	Russell	Robert J	4,030	9.80%	395
N.	Kumar	Pankaj	1,663	34.00%	565
O.	Kessler	Tristan	6,787	34.00%	2,308

$ 23,068

Labor and fringe benefits are applied in the following manner:

Full Fringe	Total direct labor dollars except casual labor.
Casual Fringe	Total direct labor dollars for casual labor.
Home & Branch Overhead applicable full fringe benefits.	Total direct labor dollars for Home & Branch labor plus
Field Overhead	Total Field direct labor dollars plus applicable full fringe.
Field Casual Overhead fringe.	Total Casual direct labor dollars plus applicable casual
Strategic Mid H&B Overhead applicable full fringe.	Total Strategic Mid H&B direct labor dollars plus
Strategic Mid Field Overhead applicable full fringe.	Total Strategic Mid Field direct labor dollars plus
Strategic Low Field Overhead applicable full fringe.	Total Strategic Low Field direct labor dollars plus
Consulting G&A G&A expenses.	Total costs excluding direct materials, subcontracts, and
Subcontract Administration	Total subcontract costs.

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2. Subcontractors & Consultants

List all subcontractors and consultants. **Also submit separate Budget Submittal Form for each subcontractor and consultant.**

	Subcontractor or consultant		Cost
A.	Life Cycle Associates	Labor	63,000
B.	SDV SCC	Labor	14,638

Subtotal: $ 77,638

Stefan Unnasch is a Senior Partner at Life Cycle Associates who will be serving as a technical expert for the lifecycle analyses. Mr. Unnasch has performed fuel cycle analysis studies since 1987 were he developed analytical approaches that take into account the environmental constraints that apply to California. He develops models of well-to-wheel energy impacts and emissions including criteria pollutants, toxics, greenhouse gases, and global energy inputs. These analyses have included assessing the resource mix and transportation modes for fuel production, process modeling of fuel production plants, and vehicle drive cycle analysis. He has developed spreadsheet and database models that enable the calculation of regional specific emissions as part of a full fuel cycle analysis. His work on California fuel cycle analysis efforts includes serving as the Co-Chairman of the Societal Benefits Topic Team for the California Hydrogen Highway Blueprint Plan, support of California AB1007, and the Low Carbon Fuel Standard. Mr. Unnasch was a participant in Annex XI, Life Cycle of Fuels, and Annex XV Fuel Cell Systems for Transportation under the International Energy Agency Operating Agreements. In this effort, he worked with a group of international experts on assessing the lifecycle emissions from conventional and alternative fuels. He also was the key U.S. contributor to Annex XV, Fuel Cell Systems for Transportation.

Richard Plevin, a senior partner at Life Cycle Associates will also be conduction the lifecyle analysis portion of this project. Mr. Plevin has developed energy and greenhouse gas studies of ethanol production systems for fuel producers, regulators (in the UK), and for scientific publications. His masters paper at UC Berkeley focused on the differential climate impacts of biofuel production systems, and the uncertainties therein. Mr. Plevin was a member of the UC Berkeley study team preparing a report on the state's Low Carbon Fuel Standard for the California Air Resources Board. He co-authored the sections of the report dealing with biofuels, life cycle analysis, uncertainty, and compliance. He also served as peer reviewer for the biofuels sections of the AB 1007 Full Fuel Cycle Analysis study. Richard co-developed the ERG Biofuel Analysis Meta-Model (EBAMM) to compare six bioethanol energy analyses to understand the divergence in published results. He lead the model design and implementation effort, and contributed significantly to the highly-cited paper published in Science, January 2006, as well as the extensive Supporting Online Materials. Mr. Plevin is a co-author of Life Cycle Associates' BEACCON (Biofuels Emissions and Cost Connection) model, which estimates life cycle emissions, energy, and cost for corn ethanol production.

Brent Riffel is an engineer at SDV-SCC, Inc., where he conducts lifecycle emissions and energy analyses and cost estimation for conventional and alternative fuel pathways. He is experienced with developing LCA tools and providing support for public policy making. Mr. Riffel has conducted lifecycle analysis since 2003 using the GREET and LEM models. He has

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performed numerous scenario analyses and examined the uncertainty and sensitivity of model results. Brent has provided results to numerous organizations, including UC Davis, California Air Resources Board, CEC and Argonne National Lab. He is extremely familiar with both models and has expanded the LEM and built custom analytical tools using components from GREET. Brent is also a co-author of the BEACCON (Biofuels Emissions and Cost Connection) model, which estimates lifecycle emissions, energy and cost for corn ethanol production.

Robert Ewing is the owner and founder of ICF's subcontractor, SDV-SCC, Inc., a Disabled Veteran Business Enterprise (DVBE) and Small Business Enterprise (SBE), Certified by the Office of Small Business and DVBE Services, Department of General Services, State of California, Mr. Ewing has experience in complex startup and turnaround situations, financial management, organizational development, and systems planning and implementation.

3. Equipment (itemize)

	Item	Cost
A.	None	0.00

Subtotal: $ -

4. Travel and Subsistence (itemize). Use State rates (Appendix IV). NO FOREIGN TRAVEL ALLOWED.

	Description	Cost
B.	Ground Transportation	242.50
C.	Per diem or subsistence	118.00
E.	Parking	60.00

Subtotal: $ 420.50

This estimate assumes that one ICF team member, Pamela Mathis, will travel from San Francisco to Sacramento to meet with ARB for the kick-off meeting (under Task 0) and will conduct the technical presentation under Task 7. This estimate assumes that for both meetings, travel will occur for one day and one night.

5. Electronic Data Processing (itemize)

	Description	Cost
A.	None	

Subtotal: $ -

6. Photocopying & Printing (itemize)

	Description of product			Cost
A.	Photocopying & Printing	3,300	0.10	330.00

	$
Subtotal:	330

The standard federal rate for reproduction is $.10 per page. This budget estimate assumes that 3,300 pages will be photocopied.

7. Mail, Telephone & FAX (itemize)

	Item	Cost
A.	Communications	201.30
B.	Delivery/Postage	135.00
C.	Mailings	14.52

Subtotal:	$	350.82

The average cost for a long distance phone call is $1.65 per call. This estimate assumes 122 calls averaging 30 minutes will occur. A total of 9 packages will be sent at an average rate of $15 per package. Twelve mailings will be sent at a cost of $1.21 each.

8. Materials & Supplies (itemize)

	Item	Cost
A.	Publications	0.00

Subtotal:	$	-

9. Analyses (itemize)

	Description	Cost
A.	None	

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Subtotal:	$ -

10. Miscellaneous (itemize)

Item	Cost
A. None	0.00

Subtotal:	$ -

Total Direct Cost (add subtotals for categories 1-10):	$ 178,261

B. Indirect Costs

11. Overhead

Base (Salaries, total direct costs, etc.)		Rate	Cost
A.	Labor & Fringe Benefits (421)	80,180	70.05%	56,166
B.	Labor & Fringe Benefits (422)	5,598	34.21%	1,915
C.	Labor & Fringe Benefits (423)	14,602	34.21%	4,995

Subtotal:	$ 63,076

Labor and fringe benefits are applied in the following manner:

Full Fringe	Total direct labor dollars except casual labor.
Casual Fringe	Total direct labor dollars for casual labor.
Home & Branch Overhead	Total direct labor dollars for Home & Branch labor plus applicable full fringe benefits.
Field Overhead	Total Field direct labor dollars plus applicable full fringe.
Field Casual Overhead	Total Casual direct labor dollars plus applicable casual fringe.
Strategic Mid H&B Overhead	Total Strategic Mid H&B direct labor dollars plus applicable full fringe.
Strategic Mid Field Overhead	Total Strategic Mid Field direct labor dollars plus applicable full fringe.
Strategic Low Field Overhead	Total Strategic Low Field direct labor dollars plus applicable full fringe.
Consulting G&A	Total costs excluding direct materials, subcontracts, and G&A expenses.
Subcontract Administration	Total subcontract costs.

12. General and Administrative Expenses

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	Base		Rate	Cost
A.	Direct Costs (excluding Sub) + Overhead	164,557.41	15.88%	26,131.72
B.	Subcontractors & Consultants	76,780.00	3.05%	2,367.96

Subtotal: $ 28,499.68

The G&A expenses are based on standard G&A rates used for government work by ICF Consulting Services, LLC.

13. Other Indirect Costs

	Base	Rate	Cost
A.	None		

Subtotal: $ 0

14. Fee or Profit, if applicable (give details)

	Base		Rate	Cost
A.	Direct Cost (excluding Sub) + Indirect Cost (excluding Sub G&A)	190,689	10.00%	19,069
B.	Subcontractors & Consultants	79,122	10.00%	8,001

Subtotal: $ 27,070

Total Indirect Cost (add categories 11-14): $ 118,646

Total Project Cost: $ 297,765

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Cost Breakdown by Task

Item	Task 0	Task 1	Task 2	Task 3	Task 4	Task 5	TOTAL
Labor Charges	3528	2464	14401	40471	13903	2546	77312
Fringe Benefits	1074	738	4451	11560	4379	866	23068
Subcontractors & Consultants	3260	5223	4523	46086	15546	3000	77638
Equipment		0	0	0	0	0	0
Travel and Subsistence	210	0	0	0	0	210	421
Materials And Supplies		0	0	0	0	0	0
Photocopying & Printing	100	10	50	50	100	20	330
Mail, Telephone & Fax	64	8	33	141	96	8	351
Analyses		0	0	0	0	0	0
Miscellaneous		0	0	0	0	0	0
Overhead	3020	2080	12482	31197	11907	2390	63076
General and Administrative	1369	1001	5127	14653	5299	1051	28500
Other Indirect Costs		0	0	0	0	0	0
Fee or Profit	1263	1152	4107	14416	5123	1009	27070
Total	**$13,889**	**$ 12,676**	**$ 45,173**	**$ 158,574**	**$ 56,354**	**$ 11,100**	**$ 297,765**

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ICF INTERNATIONAL

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

07000.1

INDIRECT COST RATE AGREEMENT

Date: JAN 29 2007

Contractor: ICF Consulting Group, Inc.
Fairfax, VA

1. This Agreement is entered into by and between the U.S. Environmental Protection Agency (EPA) and the contractor. The purpose of this Agreement is to establish indirect cost rates applicable to all EPA contracts and subcontracts.

2. This Agreement is entered into in accordance with Federal Acquisition Regulation (FAR) 42.703.

3. Subject to the provisions listed elsewhere in this Agreement, the indirect cost rates listed below are in effect for the periods specified, applicable to EPA contracts, and are incorporated into the contracts in accordance with FAR 52.216-7 and EPAAR 1552.242-70.

Type	Effective Period From	To	Rate	Base
Billing				
Fringe Benefits				
Full Fringe	01/01/2007	12/31/2007	34.06%	(a)
Casual Fringe	01/01/2007	12/31/2007	9.80%	(b)
Overhead				
Home & Branch	01/01/2007	12/31/2007	70.05%	(c)
Field & Field Casual	01/01/2007	12/31/2007	94.21%	(d)
Strategic Mid Home & Branch	01/01/2007	12/31/2007	41.29%	(e)
Strategic Mid Field	01/01/2007	12/31/2007	18.41%	(f)
Strategic Low Field	01/01/2007	12/31/2007	11.32%	(g)
G&A	01/01/2007	12/31/2007	15.88%	(h)
Subcontract Administration	01/01/2007	12/31/2007	3.05%	(i)

Basis for Application

(a) Total labor dollars for all employees except field casual.
(b) Total labor dollars for field casual employees
(c) Direct labor, bid and proposal and subcontract administration labor dollars, plus applicable fringe benefits for all Consulting Home & Branch and Corporate Home Office employees.
(d) Direct labor, bid and proposal and subcontract administration labor dollars, plus applicable fringe benefits for all Consulting Field and Consulting Field Casual employees.
(e) Direct labor, bid and proposal and subcontract administration labor dollars, plus applicable fringe benefits for all Strategic Mid Home & Branch employees.

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070001

Contractor: ICF Consulting Group, Inc. Page 2 of 3
Fairfax, VA

Basis for Application
(f) Direct labor, bid and proposal and subcontract administration labor dollars, plus applicable fringe benefits for all Strategic Mid Field employees.
(g) Direct labor, bid and proposal and subcontract administration labor dollars, plus applicable fringe benefits for all Strategic Low Field employees.
(h) Total cost incurred, excluding direct materials, subcontracts and G&A expense.
(i) Total direct materials and subcontract costs.

4. Subcontracts. These rates apply equally to subcontracts under prime contracts subject to the cost principles in FAR Part 31 and subject to the limitations in each subcontract.

5. Incorporation of this rate agreement into the applicable contracts:

a). Shall not change any indirect cost rate ceiling, monetary ceiling, contract obligation, or specific allowance or disallowance provided in the terms and conditions of the affected contracts. For those contracts and subcontracts containing indirect cost rate ceilings which are less than the rates contained in this Agreement, final and billing rates shall not exceed the specified ceiling rates.

b). Is not a waiver by EPA of the Limitation of Cost Clause or authorization for the contractor to exceed the current estimated costs set forth in the contracts and subcontracts.

d). Shall not change or otherwise effect provisional billing rates for periods other than those cited in this agreement. Rates for periods not cited in this agreement shall be those specified in the original contract unless revised by another negotiated indirect cost rate agreement or contract modification.

6. Special Remarks.

a). The indirect cost rates contained in Paragraph 3 of this agreement are billing rates which apply only to the existing contracts and subcontracts and should not be construed to be forward pricing rates. The rates should not be used as a substitute for examining and analyzing indirect cost rates contained in current contractor proposals.

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~~Exhibit B Attachment 1~~

Contractor: ICF Consulting Group, Inc.
Fairfax, VA

b). A voucher adjusting the difference between billed indirect costs and the indirect costs resulting from the application of the negotiated indirect cost rates for the periods specified in this agreement, shall be submitted to the office specified in each contract within 60 days of the effective date of this negotiated indirect cost rate agreement.

FOR THE CONTRACTOR:

Signature

Scott E. Bressler, Controller
Name and Title

January 29, 2007
Date

FOR THE U.S. ENVIRONMENTAL PROTECTION AGENCY:

Contracting Officer's Signature

James D. Pecot
Contracting Officer
Name of Contracting Officer

JAN 29 2007
Date

Negotiated by: James Pecot 202-564-4423

Appendix 1: Budget Submittal Form for Life Cycle Associates

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Budget Submittal Form

This form is supplied for presenting budget detail to the Air Resources Board.

PLEASE TYPE OR PRINT:

Title of Proposal: Lifecycle Analysis of High-Global warming Potential Greenhouse Gas Destruction
RFP No. 07-330

Total Budget Requested: 63,000.58

Period Covered (months) 12

Business or Institution: Life Cycle Associates

Address: 985 Portola Rd
Portola Valley, CA 94028

Name of person authorized to bind this Stefan Unnasch

Title: Senior Partner **Phone:** (650) 461-9048

Signature of person authorized to bind this bid: Stefan Unnasch

Budget Summary

Direct Costs

1.	Labor & Employee Fringe Benefits	$ 37,401.00
2.	Subcontractor(s)/Consultant(s)	$ -
3.	Equipment	$ -
4.	Travel & Subsistence	$ -
5.	Electronic Data Processing	$ -
6.	Photocopying & Printing	$ -
7.	Mail, Telephone, and FAX	$ -
8.	Materials & Supplies	$ -
9.	Analyses	$ -
10.	Miscellaneous	$ -
	Total Direct Cost	$ 37,401.00

Indirect Costs

11.	Overhead	$ 18,700.50
12.	General & Administrative Expenses	$ 2,805.08
13.	Other Indirect Costs	$ -
14.	Fee or Profit	$ 4,094.01
	Total Indirect Cost	$ 25,599.58

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Total Direct and Indirect Cost:	$ 63,000.58

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Budget Detail
A. Direct Costs

1a. Labor Charges

	Individual's Name	Work Title	Est. Hours	Rate/Hour	Cost
A.	Stefan Unnasch	Senior Partner	220.00	65.00	14,300.00
B.	Rich Plevin	Senior Partner	200.00	65.00	13,000.00

(use additional page if necessary)

Subtotal: 27,300.00

Cost justifications. Describe exactly why each individual listed in the Budget Detail is needed in this project (i.e., their role in the project), and why this particular person was chosen for this role, and why their proposed level of effort is necessary. Describe, for each position listed, why the specified rate is reasonable or competitive. (Use additional page if necessary).

1b. Fringe Benefits

	Individual's Name	BASE ($)	RATE (%)	COST
A.	Stefan Unnasch	14300.00	37.00%	5,291.00
B.	Rich Plevin	13000.00	37.00%	4,810.00

(use additional page if necessary)

Subtotal: 10,101.00

Cost justifications. Provide the Basis for Fringe Benefit Rates (use additional page if necessary).

2. Subcontractors & Consultants

List all subcontractors and consultants. **Also submit separate Budget Submittal Form for each subcontractor and consultant.**

	Subcontractor or consultant	Cost
A.	None	

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(use additional page if necessary)

Subtotal: 0.00

3. Equipment (itemize)

	Item	Cost
A.	None	0.00

(use additional page if necessary)

Subtotal: 0.00

4. Travel and Subsistence (itemize). Use State rates (Appendix IV). NO FOREIGN TRAVEL ALLOWED.

	Description	Cost
A.	Air Transportation	0.00
B.	Ground Transportation	0.00
C.	Per diem or subsistence	0.00
D.	Other (mileage)	0.00
E.	Parking	0.00

Subtotal: 0.00

5. Electronic Data Processing (itemize)

	Description	Cost
A.	Computer equipment	0.00
B.	Computer time	0.00

Subtotal: 0.00

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6. Photocopying & Printing (itemize)

	Description of product		Cost
A.	Photocopying & Printing	0.10	0.00

Subtotal: 0.00

7. Mail, Telephone & FAX (itemize)

	Item	Cost
A.	Communications	
B.	Delivery/Postage	

Subtotal: 0.00

8. Materials & Supplies (itemize)

	Item	Cost
A.	None	0.00

Subtotal: 0.00

9. Analyses (itemize)

	Description	Cost
A.	None	0.00

Subtotal 0.00

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

:

10 **Miscellaneous** (itemize)

	Item	Cost
A.	None	0.00

Subtotal : 0.00

Total Direct Cost (add subtotals for categories 1-10): 37,401.00

B. Indirect Costs

11 **Overhead**

	Base (Salaries, total direct costs, etc.)		Rate	Cost
A.	Labor & Fringe Benefits	37401.00	50.00%	18,700.50

Subtotal : 18,700.50

Cost Justifications. Have you used federally-approved or lower rates or schedules for computing general and administrative rates for this proposal? If yes, please include a copy of the letter from the reviewing agency approving the rates used for this proposal. If no, please give the reasons below and explain how your rates are competitive. (Use additional page if necessary).

12 **General and Administrative Expenses**

	Base		Rate	Cost
A.	Direct Costs (excluding Sub) + Overhead	56,101.50	5.00%	2,805.08
B.	Subcontractors & Consultants	0.00	5.00%	0.00
C.				

Subtotal : 2,805.08

Cost Justifications. Have you used federally-approved or lower rates or schedules for computing general and administrative rates for this proposal? If yes, please include a copy of the letter from the reviewing agency approving the rates used for this proposal. If no, please give the reasons below and explain how your rates are competitive. (Use additional page if necessary).

13. Other Indirect Costs

	Base	Rate	Cost
A.	None		

Subtotal : 0.00

14. Fee or Profit, if applicable (give details)

	Base		Rate	Cost
A.	Direct Cost (excluding Sub) + Indirect Cost (excluding Sub G&A)	58,906.58	6.95%	4,094.01
B.	Subcontractors & Consultants	0.00	0.00%	0.00

Subtotal : 4,094.01

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Total Indirect Cost (add categories 11-14):	25,599.58

Total Project Cost:	63,000.58

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

Cost Breakdown by Task

Item	Task 0	Task 1	Task 2	Task 3	Task 4	Task 5	TOTAL
Labor Charges	$1,300	$1,300	$1,560	$15,340	$6,500	$1,300	$27,300
Fringe Benefits	$481	$481	$577	$5,676	$2,405	$481	$10,101
Subcontractors & Consultants	$0	$0	$0	$0	$0	$0	$0
Equipment	$0	$0	$0	$0	$0	$0	$0
Travel and Subsistence	$0	$0	$0	$0	$0	$0	$0
Electronic Data Processing	$0	$0	$0	$0	$0	$0	$0
Photocopying & Printing	$0	$0	$0	$0	$0	$0	$0
Mail, Telephone & Fax	$0	$0	$0	$0	$0	$0	$0
Analyses	$0	$0	$0	$0	$0	$0	$0
Miscellaneous	$0	$0	$0	$0	$0	$0	$0
Overhead	$891	$891	$1,069	$10,508	$4,453	$891	$18,701
General and Administrative	$134	$134	$160	$1,576	$668	$134	$2,805
Other Indirect Costs	$0	$0	$0	$0	$0	$0	$0
Fee or Profit	$195	$195	$234	$2,300	$975	$195	$4,094
Total	$3,000	$3,000	$3,600	$35,400	$15,000	$3,000	$63,001

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

Appendix 2: Budget Submittal Form for SDV-SCC, Inc.

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

Budget Submittal Form

This form is supplied for presenting budget detail to the Air Resources Board.

PLEASE TYPE OR PRINT:

Title of Proposal:	Lifecycle Analysis of High-Global Warming Potential Greenhouse Gas Destruction
Total Budget Requested:	14,636.80
Period Covered (months):	12
Business or Institution:	SDV-SCC, Inc
Address:	205 De Anza Blvd, Suite 26, San Mateo, CA 94402
Name of person authorized to bind this bid:	Robert Ewing
Title:	President
Phone:	(650) 358-9522
Signature of person authorized to bind this bid:	Robert C. Ewing

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

Budget Summary

Direct Costs

1.	Labor & Employee Fringe Benefits	$ 14,636.80
2.	Subcontractor(s)/Consultant(s)	$ -
3.	Equipment	$ -
4.	Travel & Subsistence	$ -
5.	Electronic Data Processing	$ -
6.	Photocopying & Printing	$ -
7.	Mail, Telephone, and FAX	$ -
8.	Materials & Supplies	$ -
9.	Analyses	$ -
10.	Miscellaneous	$ -
	Total Direct Cost	$ 14,636.80

Indirect Costs

11.	Overhead	$ -
12.	General & Administrative Expenses	$ -
13.	Other Indirect Costs	$ -
14.	Fee or Profit	$ -
	Total Indirect Cost	$ 14,636.80

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

Total Direct and Indirect Cost:	$ 14,636.80

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

Budget Detail
A. Direct Costs

1a

Labor Charges

	Individual's Name	Work Title	Est. Hours	Rate/Hour	Cost
A.	Bob Ewing	Research Consultant	12.00	109.12	1,309.44
B.	Brent Riffel	Research Consultant	200.00	52.00	10,400.00

(use additional page if necessary)

Subtotal: 11,709.44

Cost justifications. Describe exactly why each individual listed in the Budget Detail is needed in this project (i.e., their role in the project), and why this particular person was chosen for this role, and why their proposed level of effort is necessary. Describe, for each position listed, why the specified rate is reasonable or competitive. (Use additional page if necessary).

1b

Fringe Benefits

	Individual's Name	BASE ($)	RATE (%)	COST
A.	Bob Ewing	1309.44	25.00%	327.36
B.	Brent Riffel	10400.00	25.00%	2,600.00

Subtotal: 2,927.36

2. Subcontractors & Consultants

List all subcontractors and consultants. **Also submit separate Budget Submittal Form for each subcontractor and consultant.**

	Subcontractor or consultant	Cost
A.	None	

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(use additional page if necessary)

Subtotal: 0.00

3. Equipment (itemize)

	Item	Cost
A.	None	0.00

(use additional page if necessary)

Subtotal: 0.00

4. Travel and Subsistence (itemize). Use State rates (Appendix IV). NO FOREIGN TRAVEL ALLOWED.

	Description	Cost
A.	Air Transportation	0.00
B.	Ground Transportation	0.00
C.	Per diem or subsistence	0.00
D.	Other (mileage)	0.00
E.	Parking	0.00

Subtotal: 0.00

5. Electronic Data Processing (itemize)

	Description	Cost
A.	None	0.00

Subtotal: 0.00

6. Photocopying & Printing (itemize)

Description of product	Cost

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

A.	None	0.10	0.00

Subtotal: 0.00

7. Mail, Telephone & FAX (itemize)

	Item	Cost
A.	None	

Subtotal: 0.00

8. Materials & Supplies (itemize)

	Item	Cost
A.	None	0.00

Subtotal: 0.00

9. Analyses (itemize)

	Description	Cost
A.	None	0.00

Subtotal: 0.00

10. Miscellaneous (itemize)

	Item	Cost
A.	None	0.00

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

Subtotal:	0.00

Total Direct Cost (add subtotals for categories 1-10):	14,636.80

B. Indirect Costs

11

Overhead

	Base (Salaries, total direct costs, etc.)	Rate	Cost
A. Labor & Fringe Benefits	14636.80	0.00%	0.00

Subtotal:	0.00

Cost Justifications. Have you used federally-approved or lower rates or schedules for computing general and administrative rates for this proposal? If yes, please include a copy of the letter from the reviewing agency approving the rates used for this proposal. If no, please give the reasons below and explain how your rates are competitive. (Use additional page if necessary).

12

General and Administrative Expenses

	Base	Rate	Cost
A.	Direct Costs (excluding Sub) + Overhead	14,636.80	0.00%	0.00
B.	Subcontractors & Consultants	0.00	0.00%	0.00

Subtotal:	0.00

Cost Justifications. Have you used federally-approved or lower rates or schedules for computing general and administrative rates for this proposal? If yes, please include a copy of the letter from the reviewing agency approving the rates used for this proposal. If no, please give the reasons below and explain how your rates are competitive. (Use additional page if necessary).

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

13

Other Indirect Costs

	Base	Rate	Cost
A.	None		

Subtotal: 0.00

14

Fee or Profit, if applicable (give details)

	Base	Rate	Cost
A.	Direct Cost (excluding Sub) + Indirect Cost (excluding Sub G&A)	14,636.80 0.00%	0.00
B.	Subcontractors & Consultants	0.00 0.00%	0.00

Subtotal: 0.00

Total Indirect Cost (add categories 11-14): 0.00

Total Project Cost: 14,636.80

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

Cost Breakdown by Task

Item	Task 0	Task 1	Task 2	Task 3	Task 4	Task 5	TOTAL
Labor Charges	$208	$1,778	$738	$8,548	$436	$0	$11,709
Fringe Benefits	$52	$445	$185	$2,137	$109	$0	$2,927
Subcontractors & Consultants	$0	$0	$0	$0	$0	$0	$0
Equipment	$0	$0	$0	$0	$0	$0	$0
Travel and Subsistence	$0	$0	$0	$0	$0	$0	$0
Electronic Data Processing	$0	$0	$0	$0	$0	$0	$0
Photocopying & Printing	$0	$0	$0	$0	$0	$0	$0
Mail, Telephone & Fax	$0	$0	$0	$0	$0	$0	$0
Analyses	$0	$0	$0	$0	$0	$0	$0
Miscellaneous	$0	$0	$0	$0	$0	$0	$0
Overhead	$0	$0	$0	$0	$0	$0	$0
General and Administrative	$0	$0	$0	$0	$0	$0	$0
Other Indirect Costs	$0	$0	$0	$0	$0	$0	$0
Fee or Profit	$0	$0	$0	$0	$0	$0	$0
Total	$260	$2,223	$923	$10,686	$546	$0	14,636.80

USE OR DISCLOSURE OF PROPOSAL DATA IS SUBJECT TO THE RESTRICTION ON THE DISCLOSURE STATEMENT OF THIS PROPOSAL

EXHIBIT D
Standard Agreement

SPECIAL TERMS AND CONDITIONS

1. **Excise Tax**

   The State of California is exempt from federal excise taxes, and no payment will be made for any taxes levied on employees' wages. The State will pay for any applicable State of California or local sales or use taxes on the services rendered or equipment or parts supplied pursuant to this Agreement. California may pay any applicable sales and use tax imposed by another state.

2. **Settlement of Disputes**

   A. In the event of a dispute, Contractor shall file a "Notice of Dispute" with ARB within ten (10) days of discovery of the problem. Within ten (10) days, ARB shall meet with the Contractor and Project Representative for purposes of resolving the dispute.

   B. Any dispute concerning a question of fact arising under the terms of this Agreement which is not disposed of within a reasonable period of time by Contractor and State employees normally responsible for the administration of this Agreement shall be brought to the attention of the Executive Officer or designated representative of each organization for resolution. The decision of the State Executive Officer or designated representative shall be final.

   C. In the event of a dispute, the language contained within this Agreement shall prevail over any other language including that of the proposal.

   D. The existence of a dispute not fully resolved shall not delay Contractor to continue with the responsibilities under this Agreement which is not affected by the dispute.

3. **Potential Subcontractors**

   Nothing contained in this Agreement or otherwise, shall create any contractual relation between the State and any subcontractors, and no subcontract shall relieve the Contractor of his responsibilities and obligations hereunder. The Contractor agrees to be as fully responsible to the State for the acts and omissions of its subcontractors and of persons either directly or indirectly employed by any of them as it is for the acts and omissions of persons directly employed by the Contractor. The Contractor's obligation to pay its subcontractors is an independent obligation from the State's obligation to make payments to the Contractor. As a result, the State shall have no obligation to pay or to enforce the payment of any moneys to any subcontractor.

   Contractor shall not subcontract any services under this Agreement without prior approval of the State.

4. **Stop Work Order**

   State reserves the right to issue an order to stop work in the event that a dispute should arise, or in the event that State gives Contractor a notice that the Agreement will be terminated. The stop-work order will be in effect until the dispute has been resolved or the Agreement has been terminated.

EXHIBIT D
Standard Agreement

5. **Termination**

A. In addition to the rights under Exhibit C of the Standard Agreement, State reserves the right to terminate this Agreement at its sole discretion at any time upon thirty (30) days prior written notice to Contractor.

B. In the case of early termination, Contractor shall submit an invoice in triplicate and a report in triplicate covering services to termination date, following the invoice and progress report requirements of this Agreement. A copy and description of any data collected up to termination date shall also be provided to State.

C. Upon receipt of the invoice, progress report, and data, a final payment will be made to Contractor. This payment shall be for all State-approved, actually-incurred costs that in the opinion of State are justified, and shall include labor, and materials purchased or utilized (including all non-cancellable commitments) to termination date, and pro rata indirect costs as specified in the proposal budget.

6. **Amendments**

ARB reserves the right to amend this Agreement for additional time and/or additional funding.

EXHIBIT E
Standard Agreement

1. The insurer will not cancel the insured's coverage without thirty (30) days prior written notice to State; and
2. The State of California, its officers, agents, employees and servants are included as additional insured, but only insofar as the operations under this Agreement are concerned.

13. **Copyrightable Materials**

A. ARB reserves the right to any copyrightable materials developed under this Agreement. Upon acceptance of the copyrightable materials developed under this Agreement, and payment of the sums then due under the terms of the Agreement, ARB shall have the sole and exclusive right, title, and interest (including trade secret and copyright interests) in the copyrightable materials. Contractor and his or her subcontractors hereby assign(s) all rights, title, and interest (including trade secret and copyright interest) in any copyrightable materials developed under this Agreement to ARB.

B. ARB, at its discretion, may grant a nonexclusive and paid-up license to Contractor and his or her subcontractors to use said copyrightable materials. Contractor and his or her subcontractors agrees to cooperate with and assist ARB to apply for and to execute any applications and/or assignments reasonably necessary to obtain any patent, copyright, trademark, or other statutory protection for all copyrightable materials.

C. Contractor and his or her subcontractors shall not disclose any copyrightable materials, any of the deliverables thereof, or any portion thereof, to any other organization or person without the written consent of ARB.

D. Contractor and his or her subcontractors shall not use the copyrightable materials, any of the deliverables thereof, or any portion thereof, in any other work performed by this Agreement subject to any license granted without the written consent of ARB.

E. Contractor's obligations under this provision shall survive the expiration or termination of this Agreement.

14. **Confidentiality**

It is expressly understood and agreed that information Contractor receives from State in performing its obligations under this Agreement may be deemed confidential by State. Therefore, Contractor agrees to:

A. Observe complete confidentiality with respect to such information, including without limitation, agreeing not to disclose or otherwise permit access to such information by any person or entity in any manner whatsoever.

B. Ensure that Contractor's employees, agents, representatives, and independent contractors are informed of the confidential nature of such information and ensure by agreement or otherwise that they are prohibited from copying or revealing, for any purpose whatsoever, the contents of such information or any part thereof, or from taking any action otherwise prohibited under this section.

EXHIBIT E
Standard Agreement

C. Not use such information or any part thereof in the performance of services to others or for the benefit of others in any form whatsoever whether gratuitously or for valuable consideration, except as permitted under this Agreement.

D. Notify State promptly and in writing of the circumstances surrounding any possession, use or knowledge of such information or any part thereof by any person other than those authorized by this paragraph.

15. **Patent Provisions**

A. Definitions

1. "Invention" means any discovery or product of creative imagination, thought, mental synthesis, or purposeful experimentation conceived or first reduced to practice in the course of or under this Agreement. The term "invention" includes, but is not limited to, any art, method, process, device, machine, manufacture, design, or composition of matter, or any new and useful improvement or application thereof, or any variety of plant, that is or may be patentable under the patent laws of the United States of America.

2. "Agreement" means any legally enforceable agreement, covenant, compact grant, or other arrangement or subcontract setting forth terms and conditions to do or not to do something and entered into by or for the benefit of the State where a purpose of the agreement is the conduct of experimental, developmental, or research work.

3. "Subcontract" means an agreement under or subordinate to a previous or prime agreement, including this Agreement.

4. "Subcontractor" means an individual or firm that contract with Contractor to perform part or all of the prime Contractor's work under this Agreement.

5. "To bring to the point of practical application" means to manufacture in the case of a composition or product, to practice in the case of a process, or to operate in the case of a machine, device, or system and, in each case, under such conditions as to establish that the invention is being worked, operated, or utilized, and that its benefits are reasonably accessible to the public.

B. Rights Granted to the State

Contractor agrees to grant to State all right, title, and interest in and to each invention discovered, conceived, or first reduced to practical application during performance of this Agreement, subject to the reservation of a non-exclusive paid-up worldwide license to Contractor.

C. Invention Disclosures and Reports

With respect to each invention, Contractor shall furnish to ARB:

1. A written disclosure of each invention within six (6) months after conception or first actual reduction to practice, whichever occurs first under this Agreement, sufficiently complete in technical detail to convey to one skilled in the art to which the invention pertains a clear

EXHIBIT E
Standard Agreement

understanding to the nature, purpose, and operation, and the physical, chemical, and electrical characteristics of the invention;

2. A final report listing all inventions, including all those previously disclosed, or certifying that there are no inventions prior to final payment under this contract.

3. Information in writing, as soon as is practicable, of the date and identity of any public use, sale, or publication of any such invention made by or known to Contractor, or of any contemplated publication by Contractor;

4. Upon request, such duly executed instruments and other papers as deemed by ARB necessary to vest in State the rights granted it under this patent provision and to enable State

   to apply for and prosecute any patent application in any country covering such invention where State has the right under this patent provision to file such application; and upon request, an irrevocable power of attorney to inspect and make copies of any United States patent application filed by or on behalf of Contractor. This demand may also be made under subdivision 8.

D. Licenses Granted by Contractor to Others Subject to State's Rights

Contractor recognizes that State may contract for property or services with respect to which the vendor may be liable to Contractor for royalties for the use of an invention on account of such a contract. Contractor further recognizes that it is the policy of State not to pay, in connection with its agreements, charges for use of patents in which the State holds title. In recognition of this policy, Contractor agrees to participate in and make appropriate arrangements for the exclusion of such charges from such agreements or for the refund of amounts received by Contractor with respect to any such charges not so excluded.

E. Subcontracts

1. Contractor shall, unless otherwise authorized or directed by State, include a patent rights clause containing all the terms of this patent provision in any subcontract hereunder where the purpose of the subcontract is the conduct of experimental, developmental, or research work. In the event of refusal by a subcontractor to accept this patent provision, Contractor:

   a. shall promptly submit a written report to the State setting forth the subcontractor's reasons for such refusal or the reasons Contractor is of the opinion that the inclusion of this clause would be unacceptable, and other pertinent information that may expedite disposition of this matter; and

   b. shall not proceed with the subcontract without the written authorization of State.

2. Contractor shall not, in any subcontract or by using such a subcontract as consideration thereof, acquire any rights to inventions for his/her own use (as distinguished from such rights as may be required solely to fulfill his/her agreement obligations to State in the performance of this Agreement).

EXHIBIT E
Standard Agreement

3. Contractor, at the earliest practicable date, shall also notify State in writing of any subcontract containing a patent rights clause, furnish to State a copy of such subcontract, and notify State when such subcontract is completed. It is understood that State is a third party beneficiary of any subcontract clause granting rights to State in inventions, and Contractor hereby assigns to State all the rights that Contractor would have to enforce the subcontractor's obligations for the benefit of State with respect to inventions. Contractor shall not be obligated to enforce the agreements of any subcontractor to State with regard to inventions.

F. Right to Disclose Inventions

State may duplicate and disclose reports and disclosures of inventions required to be furnished by Contractor pursuant to this patent provision.

G. Forfeiture of Rights in Unreported Inventions

Contractor shall forfeit to State all rights in any invention which Contractor fails to report to State, at or prior to the time Contractor (1) files or causes to be filed a United States or foreign application thereon, or (2) submits the final report required by 3., B of this patent provision, whichever is later, provided that Contractor shall not forfeit rights in an invention if (a) contending that the invention is not an invention, s/he nevertheless reports the invention and all the facts pertinent to Contractor's contention to State, the time specified in 3. A above, or (b) Contractor establishes that the failure to report was due entirely to causes beyond Contractor's control and without Contractor's fault or negligence. Contractor shall be deemed to hold any such forfeited invention and the patent applications and patent pertaining thereto, in trust for State pending written assignment of the invention. The right accruing to State under this paragraph shall be in addition to and shall not supersede any other rights State may have in relation to unreported inventions.

H. Examination of Records Relating to Inventions

State shall, until the expiration of three years after final payment under this agreement, have the right to examine any books, records, documents, and other supporting data of Contractor that State shall reasonably deem directly pertinent to the discovery or identification of inventions or to compliance by Contractor with the requirements of this patent provision.

16. Equipment Provisions

A. Equipment is defined as movable articles of nonexpendable property that meet the following requirements:

1. Have a normal useful life (including extended life due to repairs) of at least one year;

2. Have a unit acquisition cost of at least $5,000 for other than land and structures (for example, identical assets costing $3,000 each for a $12,000 total would not meet the requirements); and

3. Be used to conduct work under this contract, and/or

4. Any and all EDP equipment used to conduct work under this contract.

EXHIBIT E
Standard Agreement

B. The cost of equipment includes the purchase price plus all costs to acquire, install, and prepare equipment for its intended use.

C. ARB reserves the right to purchase total equipment whose cost is greater than $25,000 and any and all EDP equipment for this contract, through the State procurement process. Contractor's proposed cost of this equipment will be deducted from the total amount payable to the Contractor.

D. In the event Contractor purchases with ARB funds, procures, uses, or otherwise takes possession of equipment owned by ARB to perform work under this contract, title to such equipment shall remain with ARB and such equipment shall become ARB's equipment upon delivery thereof into Contractor's control or possession.

E. Contractor shall obtain written approval from ARB prior to the purchase of equipment that is not specifically identified and listed in the approval budget and which is valued at more than $1,000. The contract funding shall be adjusted for any equipment or supplies furnished by ARB.

F. ARB reserves the right to full and adequate access to ARB equipment.

G. The Contractor shall maintain and administer a program for the utilization, maintenance, repair, protection, and preservation of ARB equipment, whether acquired from the ARB or purchased with ARB funds from a third party, so as to assure its full availability and usefulness for performance of this contract or as long as this equipment remains in the control or possession of the Contractor. The Contractor will install upon each item of equipment a tag identifying the equipment as belonging to the ARB and will maintain location records of all equipment. The Contractor shall take steps to comply with all appropriate directions or instructions that the ARB may prescribe for the protection of ARB equipment.

H. The Contractor shall provide to ARB, with the final invoice, a final equipment inventory. The final invoice shall contain an itemization of equipment purchased with ARB funds or procured through the State procurement process, including the type of equipment, manufacturer, serial number, and cost. All ARB equipment shall be returned to the ARB in full operating condition upon termination of this contract, unless ARB approves a different disposition in writing. Disposition of the equipment shall be in accordance with the instructions from ARB, to be issued after receipt of the final inventory.

EXHIBIT F
Standard Agreement

FINAL REPORT FORMAT

The research contract Final Report (Report) is as important to the contract as the research itself. The Report is a record of the project and its results, and is used in several ways. Therefore, the Report must be well organized and contain certain specific information. The Board's Research Screening Committee (RSC) reviews all draft Final Reports, paying special attention to the Abstract and Executive Summary. If the RSC finds that the Report does not fulfill the requirements stated in this Appendix, the document will not be approved for release, and final payment for the work completed may be withheld. This Appendix outlines the requirements that must be met when producing the Report.

Note: In partial fulfillment of the Final Report requirements, the contractor shall submit a copy of the Report on a CD in PDF format and in a word-processing format, preferably in Word - Version 6.0 or later. This is in addition to the submission of any paper copies required. The diskette shall be clearly labeled with the contract title, ARB contract number, the words "Final Report", and the date the report was submitted.

Legibility. Each page of the approved Final Report must be legible and camera-ready.

Binding. The draft Report, including its appendices, must be either spiral bound or stapled, depending on size. The revised Report and its appendices should be spiral bound, except for two unbound, camera-ready originals.

Cover. Do not supply a cover for the Report. The ARB will provide its standard cover.

One-sided vs. two-sided. To conserve paper, both the draft Report and the revised Report, except for the unbound camera-ready copies, should be printed on both sides of the page. **The unbound camera-ready copies must be printed on only one side of the page.**

Title. The title of the Report should exactly duplicate the title of the contract unless a change is approved in writing by the contract manager.

Spacing. In order to conserve paper, copying costs, and postage, please use single or one-line (1) spacing.

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Page size. All pages should be of standard size (82" x 11") to allow for photo-reproduction.

Large tables or figures. Foldout or photo-reduced tables or figures are not acceptable because they cannot be readily reproduced. Large tables and figures should be presented on consecutive 82" x 11" pages, each page containing one portion of the larger chart.

Color. Color presentations are not acceptable; printing shall be black on white only.

Corporate identification. Do not include corporate identification on any page of the Final Report, except the title page.

Unit notation. Measurements in the Reports should be expressed in metric units. However, for the convenience of engineers and other scientists accustomed to using the British system, values may be given in British units as well in parentheses after the value in metric units. The expression of measurements in both systems is especially encouraged for engineering reports.

Section order. The Report should contain the following sections, in the order listed below:
Title page
Disclaimer
Acknowledgments
Table of Contents
List of Figures
List of Tables
Abstract
Executive Summary
Body of Report
References
List of inventions reported and copyrighted materials produced
Glossary of Terms, Abbreviations, and Symbols
Appendices

Page numbering. Beginning with the body of the Report, pages shall be numbered consecutively beginning with "1", including all appendices and attachments. Pages preceding the body of the Report shall be numbered consecutively, in ascending order, with small Roman numerals.
Title page. The title page should include, at a minimum, the contract number, contract title, name of the principal investigator, contractor organization, date, and this statement: "Prepared for the California Air Resources Board and the California Environmental Protection Agency"

Disclaimer. A page dedicated to this statement must follow the Title Page:

The statements and conclusions in this Report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

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Acknowledgments. Only this section should contain acknowledgments of key personnel and organizations who were associated with the project. The last paragraph of the acknowledgments must read as follows:

This Report was submitted in fulfillment of [ARB contract number and project title] by [contractor organization] under the [partial] sponsorship of the California Air Resources Board. Work was completed as of [date].

Table of Contents. This should list all the sections, chapters, and appendices, together with their page numbers. Check for completeness and correct reference to pages in the Report.

List of Figures. This list is optional if there are fewer than five illustrations.

List of Tables. This list is optional if there are fewer than five tables.

Abstract. The abstract should tell the reader, in nontechnical terms, the purpose and scope of the work undertaken, describe the work performed, and present the results obtained and conclusions. The purpose of the abstract is to provide the reader with useful information and a means of determining whether the complete document should be obtained for study. The length of the abstract should be no more than about 200 words. Only those concepts that are addressed in the executive summary should be included in the abstract.

Example of an abstract:

A recently developed ground-based instrument, employing light detecting and ranging (lidar) technology, was evaluated and found to accurately measure ozone concentrations at altitudes of up to 3,000 meters. The novel approach used in this study provides true vertical distributions of ozone concentrations aloft and better temporal coverage of these distributions than other, more common methods, such as those using aircraft and ozonesonde (balloon) techniques. The ozone and aerosol measurements from this study, in conjunction with temperature and wind measurements, will provide
a better characterization of atmospheric conditions aloft and the processes involved in the formation of unhealthful ozone concentrations than can be achieved with traditional ground-based monitors

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Executive Summary. The function of the executive summary is to inform the reader about the important aspects of the work that was done, permitting the reader to understand the research without reading the entire Report. It should state the objectives of the research and briefly describe the experimental methodology[ies] used, results, conclusions, and recommendations for further study. All of the concepts brought out in the abstract should be expanded upon in the Executive Summary. Conversely, the Executive Summary should not contain concepts that are not expanded upon in the body of the Report.

The Executive Summary will be used in several applications as written; therefore, please observe the style considerations discussed below.

Limit the Executive Summary to two pages, single spaced.

Use narrative form. Use a style and vocabulary level comparable to that in Scientific American or the New York Times.

Do not list contract tasks in lieu of discussing the methodology.

Discuss the results rather than listing them.

Avoid jargon.

Define technical terms.

Use passive voice if active voice is awkward.

Avoid the temptation to lump separate topics together in one sentence to cut down on length.

The Executive Summary should contain four sections: Background, Methods, Results, and Conclusions, described below.

The Background section. For the Background, provide a one-paragraph discussion of the reasons the research was needed. Relate the research to the Board's regulatory functions, such as establishing ambient air quality standards for the protection of human health, crops, and ecosystems; the improvement and updating of emissions inventories; and the development of air pollution control strategies.

The Methods section. At the beginning of the Methods section, state what was done in general, in one or two sentences.

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The methodology should be described in general, nontechnical terms, unless the purpose of the research was to develop a new methodology or demonstrate a new apparatus or technique. Even in those cases, technical aspects of the methodology should be kept to the minimum necessary for understanding the project. Use terminology with which the reader is likely to be familiar. If it is necessary to use technical terms, define them. Details, such as names of manufacturers and statistical analysis techniques, should be omitted.

Specify when and where the study was performed, if it is important in interpreting the results.

The findings should not be mentioned in the Methods section.

The Results section. The Results section should be a single paragraph in which the main findings are cited and their significance briefly discussed. The results should be presented as a narrative, not a list. This section must include a discussion of the implications of the work for the Board's relevant regulatory programs.

The Conclusions section. The Conclusions section should be a single short paragraph in which the results are related to the background, objectives, and methods. Again, this should be presented as a narrative rather than a list. Include a short discussion of recommendations for further study, adhering to the guidelines for the Recommendations section in the body of the Report.

Body of Report. The body of the Report should contain the details of the research, divided into the following sections:

Introduction. Clearly identify the scope and purpose of the project. Provide a general background of the project. Explicitly state the assumptions of the study. Clearly describe the hypothesis or problem the research was designed to address. Discuss previous related work and provide a brief review of the relevant literature on the topic.' .

Materials and Methods. Describe the various phases of the project, the theoretical approach to the solution of the problem being addressed, and limitations to the work. Describe the design and construction phases of the project, materials, equipment, instrumentation, and methodology. Describe quality assurance and quality control procedures used. Describe the experimental or evaluation phase of the project

Results. Present the results in an orderly and coherent sequence. Describe statistical procedures used and their assumptions. Discuss information presented in tables, figures and graphs. The titles and heading of tables, graphs, and figures, should be understandable without reference to the text. Include all necessary explanatory footnotes. Clearly indicate the measurement units used.

Discussion. Interpret the data in the context of the original hypothesis or problem. Does the data support the hypothesis or provide solutions to the research problem? If appropriate, discuss how the results compare to data from similar or related studies. What are the implications of the findings? Identify innovations or development of new techniques or processes. If appropriate, discuss cost projections and economic analyses.

Summary and Conclusions. This is the most important part of the Report because it is the section that will probably be read most frequently. This section should begin with a clear, concise statement of what, why, and how the project was done. Major results and conclusions of the study should then be

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presented, using clear, concise statements. Make sure the conclusions reached are fully supported by the results of the study. Do not overstate or overinterpret the results: It may be useful to itemize primary results and conclusions. A simple table or graph may be used to illustrate.

Recommendations. Use clear, concise statements to recommend (if appropriate) future research that is a reasonable progression of the study and can be supported by the results and discussion.

References. Use a consistent style to fully cite work referenced throughout the Report and references to closely related work, background material, and publications that offer additional information on aspects of the work. Please list these together in a separate section, following the body of the Report. If the Report is lengthy, you may list the references at the end of each chapter.

List of inventions reported and publications produced. If any inventions have been reported, or publications or pending publications have been produced as a result of the project, the titles, authors, journals or magazines, and identifying numbers that will assist in locating such information should be included in this section.

Glossary of terms, abbreviations, and symbols. When more than five of these items are used in the text of the Report, prepare a complete listing with explanations and definitions. It is expected that every abbreviation and symbol will be written out at its first appearance in the Report, with the abbreviation or symbol following in parentheses [i.e., carbon dioxide (C02)], Symbols listed in table and figure legends need not be listed in the Glossary.

Appendices. Related or additional material that is too bulky or detailed to include within the discussion portion of the Report shall be placed in appendices. If a Report has only one appendix, it should be entitled "APPENDIX". If a Report has more than one appendix, each should be designated with a capital letter (APPENDIX A, APPENDIX 8). If the appendices are too large for inclusion in the Report, they should be collated, following the binding requirements for the Report, as a separate document. The contract manager will determine whether appendices are to be included in the Report or treated separately. Page numbers of appendices included in the Report should continue the page numbering of the Report body. Pages of separated appendices should be numbered consecutively, beginning at "1".