The Feasibility of a Barrow Arctic Research Center

A National Science Foundation Report
Office of Polar Programs
Arctic Sciences Section

In collaboration with
National Ocean and Atmospheric Administration,
Department of Energy, and
Department of the Interior

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The Feasibility of a Barrow Arctic Research Center

1. Summary

This report provides a federal agency perspective of potential improvements in Barrow to meet the needs of the broad research portfolio carried out in the region. The approach focuses on mitigating current constraints on the agencies' research programs, with an eye to potential future activities. Specifically, it envisions a role for both independent agency activity, but also improved, coordinated activity and development. We do not endorse the construction of a single central building as the best solution to the most pressing needs at this time. We do endorse a series of development efforts that would meet current needs and consider future development. The most important four are to:

1. Complete the NOAA/CMDL upgrade.

2. Develop a robust IT infrastructure for the research community.

3. Develop an additional access point to the Barrow Environmental Observatory.

4. Develop a more robust process to coordinate activities and identify needs based on actual funded or planned projects.

We recognize the need to replace the Arctic Research Facility, and recommend that the Barrow Arctic Science Consortium continue to explore options that are cost-effective, and financially sustainable for the organizations (government, industry and private) that currently either do, or support research in Barrow.

2. Background

There is a long history of research undertaken at, or based from Barrow, which shall not be described in detail here. The early history of the Naval Arctic Research Laboratory is captured in the excellent recently published volume, *Fifty More Years Below Zero* (Arctic Institute of North America, 2001). However, in 1981 the Navy withdrew from the science support business in Barrow. Research became much more difficult to arrange, and the report of the U.S. Arctic Research Commission *Logistics recommendations for an Improved U.S. Arctic Research Capability* (ARCUS, 1997) called for the re-establishment of Barrow as a year-round laboratory and to improve facilities there. NSF supported two follow-on workshops that discussed potential developments specifically in Barrow with a focus on facilitating the research in and based from Barrow. The first was held in 1998 and the report developed from that workshop and follow-on discussions is published as *The Future of an Arctic Resource* (ARCUS, 1999). The report covered many aspects of the science and its support, including facilities and operational issues. One of the recommendations was to plan a new general-purpose research facility. The recommendation also stated that planning should include how a physical structure would be funded. However, the report was not clear what specific needs are to be addressed by such a facility.

In order to develop these ideas further, NSF funded a second workshop to focus on the facility needs. This workshop was held in April 2001 and the workshop report is published as *Arctic Science in the Barrow Region: Recommendations for Future Facilities* (BASC, 2002). While it recommended a new Barrow Arctic Research Center (BARC), the functioning and size of the Center were based on the science community's projection of work in Barrow, without regard to actual recent funding of science projects. Participants at the workshop also discussed research support needs other than those provided by a central facility, such as helicopter support, a local area computer network (LAN), and access to boats, but these are not well addressed in the 2002 report. Unfortunately, there was neither time to prioritize between recommended improvements, nor did the workshop address the critical issue of possible models for the funding of the construction or its continued operation.

However, as explained below, a single large central facility is not well matched to addressing the current constraints of the federal agency-funded science community. For example, for NSF-funded projects, constraints can be mitigated by improvements in the utilization of current facilities, plus additional mobile laboratory and storage space. Another critical need is to provide good internet connectivity and a LAN to access the connectivity. Similarly, NOAA's Climate Monitoring and Diagnostics Laboratory (CMDL) is currently constrained by the size and age of the current laboratory, which needs replacing.

3. Agency Programs and Needs

3.1 National Science Foundation

3.1.1 Research in Northern Alaska

NSF supports a broad spectrum of environmental research on the Alaskan North Slope. Of the more than 60 research projects funded on the North Slope, about 30 are in the Barrow area (Table 1) and a similar number are at Toolik Field Station (Table 2). Most NSF projects are funded for 1 to 3 years, but within this cycle of periodic merit review, several projects have maintained a long-term presence. Projects often build on the long history of observations at both sites, in Barrow going back more that 50 years, and at Toolik Field Station, going back 30 years. Toolik has been an NSF Long Term Ecological Research site since 1989. Research interests include studies of the upper and lower atmosphere, coastal sea ice and the terrestrial environment and hydrology. The separately-funded studies often form strong collaborations, and NSF researchers work with each other as well as projects from NOAA/CMDL, DOE Atmospheric Radiation and Monitoring (ARM), and NASA.

3.1.2 Research Support in Barrow

Nearly all NSF-funded projects in the Barrow area are field projects, with data collected at field locations in the region 5 to 50 miles from Barrow (Figure 1). Barrow's facilities, are used for lodging, transportation, and to stage research projects. Laboratory space is used to prepare experiments and equipment, trouble-shoot instrumentation, prepare samples and perform some data analysis. Further treatment of samples and data occurs at home institutions. Some projects field year-round instruments that collect and store data. For example, NSF supports the operation of a medium-frequency radar and experiments at NOAA/CMDL.

While some projects make year round observations, most projects are active in Barrow during the spring, summer and fall. A total of 150 researchers visited Barrow in association with the NSF-funded projects, with a total footprint of approximately 2600 user-days each year. The NSF science population in Barrow reaches a maximum of about 40 people which, in 2001, occurred in August.

NSF has established a cooperative agreement with the Barrow Arctic Science Consortium (BASC) to provide a variety of logistical and organizational support for NSF-funded projects. This includes supplying field equipment and workspace. The North Slope Borough contracts with BASC to operate science facilities in the Borough and to administer the Barrow Environmental Observatory (BEO), a 7,500-acre parcel of land preserved for scientific research.

NSF has tasked BASC to establish a strong dialogue with the scientists they support to develop the facilities in Barrow to meet their needs. Specifically, in April, 2001 a

Science Advisory Group (SAG) to BASC was convened to assist BASC in short- and long-range planning. Recommendations from this group have been released in a report prepared by BASC (March, 2002). The dialogue with the SAG and researchers in the Barrow area is still developing. NSF sees the SAG as a key mechanism to identify needs and improve operations and development.

Research Facilities

Approximately 5,500 ft^2 of assignable, heated workspace is currently leased for NSF researchers. Additional space is leased for BASC's administration and equipment maintenance. Space is primarily leased at the former Naval Arctic Research Laboratory (NARL) facility, built by the Navy in 1957, which is now owned and operated by the Barrow Village Native corporation, Ukpeagvik Iñupiat Corporation (UIC) and referred to as UIC-NARL (Figure 2). Leases are year-round to ensure availability at a cost of approximately $130,000 per year. Space is not contiguous, but most is within a ¼ mile area of the core space in Building 360 (Figure 3).

Space provided to each project functions for administration, unpacking, packaging, and maintenance of equipment, chemical and electronic labs, offices and observatories. To date, BASC has found adequate space for each research project to work in the UIC-NARL area. Two recent examples were obtaining a mobile building to act as a base of operations for a team flying remotely piloted vehicles and a small structure to house an MF Radar.

The general laboratory space is functional, but supports the lowest level of sophistication. Current science users would benefit from facilities that offered improved space for working on samples such as soil cores, refrigerated space, heated storage space, freezers, and equipment for using radioisotopes. Projects use trucks, snow machines, 4-wheelers, helicopters and boats to access field sites. Another constraint is access to reliable power supplies to operate instrumentation year-round in the field.

NSF scientists also work with NOAA's CMDL program. CMDL currently houses instruments and provides personnel to measure over 50 environmental variables for a variety of experiments (Figure 4). Space for additional experiments is not available. NOAA's current plans for upgrading CMDL would allow for additional experiments and limited additional facilities that would help science teams working in the surrounding area, including the adjacent Barrow Environmental Observatory (BEO).

Accommodations

Scientists are primarily housed at the NARL Hotel, but other options include a bunkhouse (3 beds), the Arctic Research Facility (ARF) operated by the North Slope Borough's Department of Wildlife Management, and hotels in Barrow (4 miles from UIC-NARL). The NARL hotel has single and double rooms with communal bathrooms and is located next door to Building 360. Most researchers consider these to be good or adequate accommodations. In June and July, months with high use, an average of 18 NSF-funded research people were housed each night. The ARF also functions as a laboratory, bunkhouse, kitchen, and equipment maintenance facility. The building is old and barely adequate for any of its intended functions. It is the least desirable space for accommodations, because it is adjacent to laboratories, which contain hazardous materials, and it offers little privacy.

The college in Building 360 provides cafeteria-style dining during the day and makes available food for take out. Even so, science teams frequently stay in the field during the extended daylight hours of the peak season and would benefit from kitchen facilities to prepare lunches and meals after hours.

Information Technology

There is almost no technology infrastructure available to NSF researchers. There is limited internet capability over standard phone lines. There is no local area network (LAN).

3.1.3 Priorities for Improvement

NSF's overall approach is to develop infrastructure matched to the current or proposed research needs. In developing plans, science (user) input is critical. Feedback provided on site visits and other communications indicate that BASC provides very good support to the NSF-funded research community. They communicate well with the research teams, both coordinating and meeting support requirements and coordinating with the local community. However, in the relatively short history of BASC a good system for recording facility use data has not been well developed.

NSF funds BASC to develop resources in line with project requirements, but as separate projects' needs have been addressed, several infrastructure gaps have been identified as constraints. Given current information, mitigation of the current constraints on NSF science would include, in approximate order of priority:

- Improved IT infrastructure, including high-bandwidth connectivity to the internet, wireless LAN in the BEO, well-structured websites including links to federal activities and data resources, plus the capability to manage and maintain these systems.
- An alternative access point for the BEO, primarily to reduce traffic through the sensitive long-term monitoring stations of NOAA, DOE and USGS. A site has been identified. Improvements would involve a short section of road and parking, line power, a wireless communication hub and modest laboratory space and warm-up area.
- Additional central laboratory space during the summer peak. To date, there has not been a need to significantly increase the level of sophistication of the laboratories.
- Additional workspace at NOAA/CMDL primarily for CMDL's own suite of experiments, including some funded by NSF, but also as a base for researchers working on the BEO (e.g., warm-up room, wireless communication hub).
- A kitchen to support off-hours food preparation.

- A boat sufficient for near-coast work.
- Portable, autonomous year-round power systems providing 100W–2kW.
- Additional "summer" staff through BASC to support improvements.
- Alternative accommodations to the ARF.

3.1.4 Recommended Next Steps and Cost Estimates

1. Continue to plan the development of a wireless LAN and broadband internet connection serving UIC-NARL federal and non-federal science–NSF, NOAA, DOE, USFWS, NASA, NSB and others. BASC does not have the technical expertise to develop a plan or manage installation and operation, therefore external expertise is necessary. $500,000.

2. Develop an alternative access point to the BEO. $250,000

3. Explore alternatives to providing additional laboratory space, and an off-hours kitchen and lounge area close to Building 360. $400,000

4. Complete NOAA/CMDL upgrade to their facility to be managed by CMDL but allowing for access by NSF, NASA, DOE. $1,650,000

5. Cooperate with UIC, NSB, USF&WS and other ARF users to plan for the replacement of the ARF. Consideration should be given to consolidation of the mechanical shop with BASC's shop (Building 2 in Figure 2). Consideration should also be given to "outsourcing" accommodations in commercial hotels and hostels of various quality and price. The remainder of functions could be filled by a combination of laboratory space in UIC-NARL region.

   The local government, as the owner and operator, should lead in working with agencies, BASC and the regional government to develop an approach to sustain the management of this facility. For example, the local government could build the facility after seeking long-term leasing arrangements with users, e.g., NSF, through the cooperative agreement with BASC. $3,000,000

3.2 NOAA/CMDL Barrow Baseline Station

3.2.1 Background on the Barrow Baseline Station

NOAA/CMDL operates a manned Atmospheric Baseline Monitoring Station near Barrow, Alaska, (71.3°N; 156.6°W) to measure changes in atmospheric climate forcing agents such as carbon dioxide (CO_2) and methane (CH_4), ozone depleting chemicals such as fluorocarbons, Arctic air pollution from Eurasia known as Arctic Haze, stratospheric ozone depletion, and surface ultraviolet radiation (UV) levels, to name only a few of the more than 200 measurements conducted at the facility. NOAA established the observatory near Barrow in 1973 in a single room, 800 ft^2 temporary building constructed by the Naval Research Laboratory and donated to NOAA. Over the intervening years the number of scientific programs conducted at the Barrow Observatory has tripled in number.

The Barrow Observatory, six miles east of Barrow, is in the center of an 80-acre parcel of land 1 mile south of a DOD communications facility. The Observatory land is bounded on the west by an 80-acre parcel of USGS land preserved for scientific research, and on the south and east by the 7,500-acre BEO. Adjacent to the main building, there is a newly constructed two-vehicle garage (1400 ft^2) with space for gas cylinder storage and equipment repairs. Additional facilities consist of a 60 ft. tall walk-up sampling tower, three elevated platforms for equipment mounting, and a number of smaller towers and instrument installations on the tundra. The Observatory property is host to a DOE Atmospheric Radiation and Monitoring (ARM) facility on the west side of the property and a newly installed NOAA/NESDIS polar orbiting satellite downlink station north of the garage. The Barrow Atmospheric Baseline Station is the farthest north of the four manned observatories operated by NOAA/CMDL; the others are at Mauna Loa, Hawaii; American Samoa; and South Pole.

Two permanent NOAA/CMDL staff operates the Barrow station six days a week. They live in Barrow in NOAA-owned housing that will be upgraded to two newly constructed, 3 bedroom homes with 2-car heated garages in FY03. The present NOAA/CMDL station chief has worked in Barrow for 18 years and the former electronic engineer, who recently transferred to the Samoa station, had been there six years. Keeping good staff in Barrow is difficult for many Federal agencies.

A view of the Barrow Observatory is presented in Figure 4. In this figure the main station building appears in the foreground, the DOE ARM site in the center top, and the DOD communications facility in the far upper right. The new garage was completed in the fall of 2001 in the same location as the old garage. The road to the Observatory has been rebuilt in a joint NOAA/DOE/NSF project since the photo was taken and the road is now useable with wheeled vehicles on all but a few days a year.

3.2.2 Why locate an Observatory at Barrow?

Most of the landmass on earth is in the northern hemisphere, as is the human population and vegetation. Human activities at lower latitudes produce air pollution that reaches high background concentrations at Barrow, Alaska, including carbon dioxide (CO_2) from fossil fuel combustion. The large forests of Russia and Canada grow in spring and summer drawing down CO_2. Combined, these two factors produce at Barrow the largest annual CO_2 flux cycle on the earth as shown in Figure 4. Also shown in Figure 4 are data at the Barrow Observatory for the greenhouse gas methane (CH_4), for stratospheric ozone destroying CFC-11, and for Arctic Haze. Models predict that the Arctic will exhibit the first and greatest climate warming from the atmospheric greenhouse effect. This warming may already be detectable in the form of advancing spring snowmelt measured in the Barrow area.

3.2.3 Current Programs and Research Trends at the Barrow Observatory

Historically, the Barrow Observatory has been host to a range of cooperative academic research programs, many of them funded by NOAA. Within the past two years, the number of academic research programs in the Arctic has increased. Because of its location and the high quality of the complementary measurements and support available at the Barrow Observatory, requests for cooperative programs at Barrow have increased to the point where there is no more space or electrical capacity to operate new programs. Future cooperative programs will be declined beginning in calendar year 2002.

A list of the core research programs at the Barrow Observatory is presented in Table 3, a list of the cooperative scientific programs at Barrow prior to 2001 in Table 4, and new programs added in 2001 and approved for 2002 are presented in Table 5. Over the 29-year lifetime of the Barrow Observatory, over 200 scientific publications have used Barrow data with many of these publications coming from cooperative programs.

3.2.4 New NESDIS Operations at Barrow and Future Opportunities

During December 2001, NOAA/National Environmental Satellite, Data, and Information System (NESDIS), with CMDL approval and assistance, installed a 3-meter receive-only High Resolution Picture Transmission station at the CMDL Barrow site to provide a downlink for "blind orbits" of the NOAA/NESDIS Polar Operational Environmental Satellite (POES) series spacecraft. The system is performing well in acceptance tests and NESDIS is now considering adding a 13-meter dish and a dedicated T-1 link to the Barrow Observatory. The T-1 will come in the summer of 2002 and the antenna later. This new downlink facility will need new space at the Barrow Observatory and NESDIS may consider contributing to construction of new space and paying for up to 50% of a NOAA/CMDL staff member to monitor and maintain the downlink.

3.2.5 Anticipated Needs to Support the Study of Environmental Arctic Change (SEARCH)

Because of the unprecedented changes that have occurred in the Arctic over the past few decades, and the projections of even greater change over the next one-hundred years, nine U.S. government agencies have joined to undertake the Study of Environmental Arctic Change. A science plan, prepared by experts drawn from all relevant scientific disciplines, defines a strategy calling for observation, modeling, process studies, and application to human needs. The draft implementation plan calls for comprehensive environmental observation as the highest priority. Undertaking the necessarily long-term and site-specific observation program will require facilities and capabilities above those that already exist in the Arctic.

Among the types of observations that are needed are: meteorology, gases, and aerosols throughout the atmospheric column; land surface measurements (permafrost, snow cover, soil moisture, plant cover, plant growth, gas flux, surface albedo); incoming and outgoing radiation; river and stream flows; and observations of shore-fast ice and coastal wave energy. All of these types of measurements are needed somewhere on the Alaskan North Slope. Facilities for some of these measurements exist already at Barrow, but others will have to be developed. In addition, measurements outside of Barrow proper, and distributed along the entire North Slope will be needed. A means of transmitting data, preferably in real-time from each measurement site will be required as well. In Barrow and at other locations, there will be need for utilities, housing, transportation and food for the scientists involved in making these measurements, as well as for buildings, platforms or other facilities for instruments.

Specific needs on the North Slope to support all of the activities being planned for SEARCH cannot be stated at this time. Specific needs for activities beginning in 2003 are already included in the agency descriptions. These include the NOAA priority for increased capacity at the NOAA Barrow Observatory for atmospheric measurements and for visiting scientists

3.2.6 Expand the NOAA Facility to Accommodate Arctic Research

Considering the unique location of the CMDL facility, the long record of measurements, the presence of a trained staff living in permanent housing in Barrow, and the possibility of leveraging CMDL, NESDIS, USGS and NSF resources, we suggest that any planned construction of atmospheric scientific research facilities in the Barrow area consider the NOAA/CMDL site. Since the NOAA site is on Federal land, building and similar permits are not required thus saving months (if not years) in the construction cycle. Also, since the Barrow Observatory site is located in an area protected by large buffers of controlled land, encroachment and unfriendly neighbor issues are non-existent.

Anticipating possible future expansion at the Barrow Observatory, NOAA/CMDL upgraded electrical power transformer and distribution capacity during the just completed construction of the new garage/cylinder storage building. This would reduce future construction costs. NOAA/Mountain Administrative Support Center (MASC) in Boulder has many years of experience designing and overseeing construction of facilities on the permafrost at the Barrow site. These engineering facilities would be available for design, contract award, and construction management of any new structures at the CMDL Barrow facility at no cost to the project other than travel expenses for engineers. This could save up to 10–15% of overall construction costs.

NOAA proposes a relatively modest (2400 ft^2) building that would include laboratory and office space, water tank and waste holding tanks, sanitary facilities, a small kitchen area, and adequate electricity distribution for current and projected scientific and satellite monitoring programs. The new building would be near the present Barrow Observatory buildings and joined to them by a covered walkway. The present observatory building would be brought up to current fire code and be used as an instrument assembly and shipping area, and for flask and supply storage. The new facility, combined with the present, would accommodate up to eight staff and would provide for double the number of programs that can be supported by the present facility.

3.2.7 Projected Costs for a State of the Art Facility at the Barrow Observatory Site

Based upon construction costs of the just completed garage/cylinder storage building at the Barrow site, NOAA/MASC has calculated that a high quality laboratory facility could be constructed for \$500 per ft^2 inclusive of all architectural, engineering and construction management costs and office furnishings for 8 personnel. Thus, a 2400 ft^2 building would cost \$1.2 million. Depending upon the amount of power required in the new building and for operation of the NESDIS satellite antenna links, upgraded transmission lines may have to be run to the station at a cost of about \$300 k. Adequate transformers are in place to handle about 50% additional power requirements at the site. Rehabilitation of the original Observatory building would cost in the region of \$150,000 to bring it up to present fire and safety standards for use as a warm storage facility.

Construction of the new building could begin within a year or less of a decision to go forward and could be completed in about six months. Pilings would have to be driven in the winter of one year with construction beginning the following fall.

3.3 Department of Energy/Atmospheric Radiation and Monitoring

Since the ARM North Slope of Alaska (NSA) and adjacent Arctic Ocean climate change research site began to be actively developed in 1997, it has depended on the local science support capabilities of the Barrow community to meet its needs. Those needs have been met almost entirely through contracts first with BASC, and then with UIC Science Division. These capabilities were developed primarily to support NSF-funded research on the North Slope, since NSF spends considerably more in this area than the other agencies combined. Hence, improvement in the capabilities to support NSF-funded research translates directly into improvement in local capabilities to support DOE/ARM and other agency projects in the vicinity. Of particular value to DOE/ARM would be improvement in the availability of selected heavy equipment: fork lifts, cranes, etc. Since the partial closure of UIC Construction in Barrow during this past year, arrangements for the use of such equipment are no longer easily made.

There are a number of other ways in which the additional facilities proposed for BARC could benefit DOE/ARM. Presently, the ARM/NSA Operations Center and lodging facilities are in a duplex that it leases from BASC. ARM notes that the current duplex is one meter above sea level and vulnerable to decadal flooding events. The proposed additional facilities for BARC would be on pilings sufficiently high that the new facilities would be immune from any probable storm surge. Hence, if appropriate arrangements could be made to move the present ARM Operations Center into the new BARC facilities, ARM could avoid damage that could well exceed \$100K.

If the proposed BARC facilities included a high bandwidth data pipe, say in excess of T1, and if a suitable and cost-effective sharing arrangement could be worked out, it would be of substantial benefit to ARM. Prior to early calendar year 2001, ARM had its own T1 line to Barrow. Then the federal telecommunication system contract was re-negotiated, and the cost of the T1 line more than quadrupled to over \$14K/month. ARM could not afford that, so the T1 line was replaced with a 256K line. The smaller bandwidth data pipe is not entirely satisfactory even now, and limits further expected growth.

In the FY03-04 time frame, it is proposed that the ARM Cloud and Radiation Test-bed sites, not only on the North Slope, but also in the Southern Great Plains and the Tropical Western Pacific, become "User Facilities"—that is, that a program be undertaken to encourage the use of these facilities and the data streams they produce by researchers from outside of ARM, DOE and even, from outside the U.S. It would appear that potential inclusion of the ARM NSA Operations Center in the proposed BARC facilities would go a long way towards encouraging the desired larger client base for the ARM NSA/AAO facilities and data streams. The ARM data could be made available in near real time to researchers working at the BARC regardless of agency affiliation or country of origin. Visiting researchers to the BARC could also be educated in the procedures for obtaining retrospective and/or future ARM NSA data sets through the internet. Ideally, the result would be a much more complete integration of the ARM NSA/AAO facility with the rest of the Arctic Research Community. In light of FY03 marking the beginning of explicit funding for SEARCH (Study of Environmental Arctic Change), this would seem very timely.

3.4 Department of the Interior – U.S. Fish and Wildlife Service

Several Service offices conduct work in and around Barrow, including Ecological Services, Marine Mammals Management, and Migratory Bird Management offices. Staff from the Service's Refuges, Subsistence Management, and Law Enforcement programs regularly attend meetings or conduct other business in Barrow, but do not generally conduct field work requiring support facilities in Barrow. The Ecological Services Fairbanks office is the primary current and future Service user of Barrow facilities, specifically in support of field studies of the threatened Steller's eider. Because the Service no longer has a specific Research Division, it is unlikely that the Service's need for Barrow facilities for research support will increase over its current level in the near future.

USF&W has conducted Steller's eider studies in the Barrow area since 1991 in cooperation with the North Slope Borough's Department of Wildlife Management. Their support needs include housing, office and lab space, and vehicles. As part of the cooperative effort, the North Slope Borough has provided sleeping, office and lab accommodations at the Arctic Research Facility (ARF). In a typical summer, USFWS employs two wildlife technicians on-site in Barrow from June through August. In addition, in recent years we have conducted intensive ground surveys to identify potential nesting areas. This effort is labor-intensive, involving up to 10 additional employees over a 3–4 week period in June. In 2001, they rented an apartment in Barrow to house the field crew, since adequate bunk-space was not available at the ARF; they anticipate the need to do the same in 2002. To fulfill vehicle needs, they have rented pickup trucks and shipped 4-wheelers to Barrow for summer use.

The Steller's eider field studies are supported by base funds provided for recovery of listed species rather than from specific research project funds. Logistical support provided by the Borough amounts to an estimated $6,000–$8,000 annually. Unfortunately, current support arrangements are untenable in the long term, simply because the ARF is aging and crowded and its long-term availability is questionable.

The availability of a science center in Barrow could be extremely beneficial to USF&WS' field studies. They are concerned, however, that such a facility may cost too much for the Service to use if the "full service" option is the only one available. They encourage facility designs which could support a range of research budgets, suggesting that needs could potentially be met through modular units providing sleeping quarters, bath, kitchen, office and lab space; such units could be shut down in winter but made available in summer. At the lowest end, accommodation for temporary placement of weatherport facilities could allow low-budget field projects to be conducted.

Despite their limited field project budget, the Service is very supportive of the establishment of an arctic science support facility in Barrow. In addition to support for their own field studies, such a facility will encourage studies by others, which will contribute to an understanding of arctic ecosystems, migratory birds, fish, marine mammals, and environmental contaminants. Such information will contribute significantly to the Service's mission to conserve public trust resources.

It is unlikely that the Service would be able to provide funds for the construction of a science support facility based on current funding levels. However, one potential option is to develop a budget initiative for additional allocated funds to support such a facility. Budget initiatives are often time-consuming and competition for funds is high, but it is an option that could be pursued if a specific purpose with associated budget needs is identified. This is one option and approval for such an approach would need to come both from the USF&WS Regional Director and the Washington Office.

3.5 NASA

A 1 km x 1 km site in the Barrow Environmental Observatory has been proposed as a Land Validation Core site for the Earth Observing System, specifically for the Moderate Resolution Imaging Spectroradiometer (MODIS). The site would be used for validation of remotely sensed and satellite derived products, including net primary production (NPP), leaf area index (LAI) and photosynthesis. There are presently 31 core sites selected worldwide, and this is the only one that represents the Arctic tundra biome.

4. Synthesis of Federal Program Needs for Development

Agencies have largely taken an independent approach to meeting their research support needs in Barrow. This is appropriate for the most part, but it is clear that improved coordination will likely bring benefits to the conduct of research. While below we recommend several steps to improve infrastructure we emphasize that improved interagency coordination of plans is needed now and in the future.

We believe that in principle, the Barrow Arctic Science Consortium is well placed to facilitate this coordination, as BASC evolves into an organization that can provide synthesis of organizational needs at all levels of government, and outside government. BASC must continue to learn how to facilitate research before it is tasked to lead in the design, construction and operation a potentially expensive and sophisticated research center, which is well outside BASC's current area of expertise. While NSF has taken a lead in funding and developing BASC, BASC must develop relationships with other agencies that should fund the support they are provided. BASC has an excellent history of dialogue with individual research projects they are tasked to support, and can articulate needs and provide effective options to meet them. While BASC performs well in supporting scientists logistics needs, they need to significantly improve their business approach, and their approach to developing sound long term plans. This is not said in criticism, but acknowledges a normal organizational development cycle. We thus support a gradual infrastructure development, as required by the current science tasks.

It is clear given changes in the North Slope Borough government that development of an option to replace the ARF is a priority, but it is not clear how this can be best done, and the resulting facility managed and funded over the long term. The primary users of the current facility are not federal research programs. Nor do most of the current users contribute to the ARF's operation and maintenance. This lack of viable support of the current ARF raises questions about the long-term feasibility of a BARC. Agencies are comfortable to fund (own or lease) space for facilities to support projects they have selected for their programs, but no agencies wish to underwrite a facility that may place open-ended demands on it in the future.

5. Recommendations

No federal agency is planning a significant and sustained increase in research activity at Barrow. The level of research has grown gradually in recent years, but it is unlikely that research budgets in general would support rapid growth, even with SEARCH, which must support observations throughout the Arctic to be effective. The drivers for development should therefore be based around the current and planned research portfolio and known constraints.

1. Complete the NOAA/CMDL upgrade.

    Plans for this upgrade are mature, and well justified. A new facility would be able to support NOAA/CMDL's work, the likely to require expansion with SEARCH, and function as a local hub for associated NSF and DOE activities. It should continue to function as an access point to the BEO. Implementation is estimated at $1,650,000

2. Develop a robust IT infrastructure for the research community.

    Develop a wireless LAN and broadband internet connection serving UIC-NARL federal and none federal science – NSF, NOAA, DOE, USFWS, NASA, NSB and others. The wide-band capability may be built around the NESDIS requirement. As BASC do not have the technical expertise to develop a plan or manage installation and operation, external expertise is necessary. Implementation is estimated at $1,000,000.

3. Develop an additional access point to the Barrow Environment Observatory.

    Develop an alternative access point for the BEO, primarily to reduce traffic through the sensitive long-term monitoring stations of NOAA, DOE and USGS. A site has been identified in the draft BEO science plan, close to NASA’s proposed site for assessment of MODIS satellite imagery. Improvements would involve a short section of road and parking, line power, a wireless communication hub and modest laboratory space and warm-up area. Implementation is estimated at $200,000.

4. Develop a robust process to coordinate activities and identify needs based on actual funded or planned projects.

    We believe this is best tasked to BASC, and improved coordination would probably require an additional full-time equivalent for their staff. In additional, coordination would include improving access to data though linking directories and revitalizing the NSB GIS, possibly managed by an academic institution. Implementation is estimated at $200,000.

5. Additional laboratories for summer peak.

   NSF would propose to lease additional space through BASC from UIC, as need to accommodate the varying number of funded research projects, as it has done in the past. Implementation is estimated at $200,000

6. Improved kitchen and lounge available off-hours.

   This could be provided by refurbishment of one of the current housing modules in UIC/NARL, or providing a purpose built trailer. Researchers from NSF, USF&WS, and NASA would benefit. Implementation is estimated at $200,000.

Total Estimated Cost for Recommended Improvements: $3,450,000

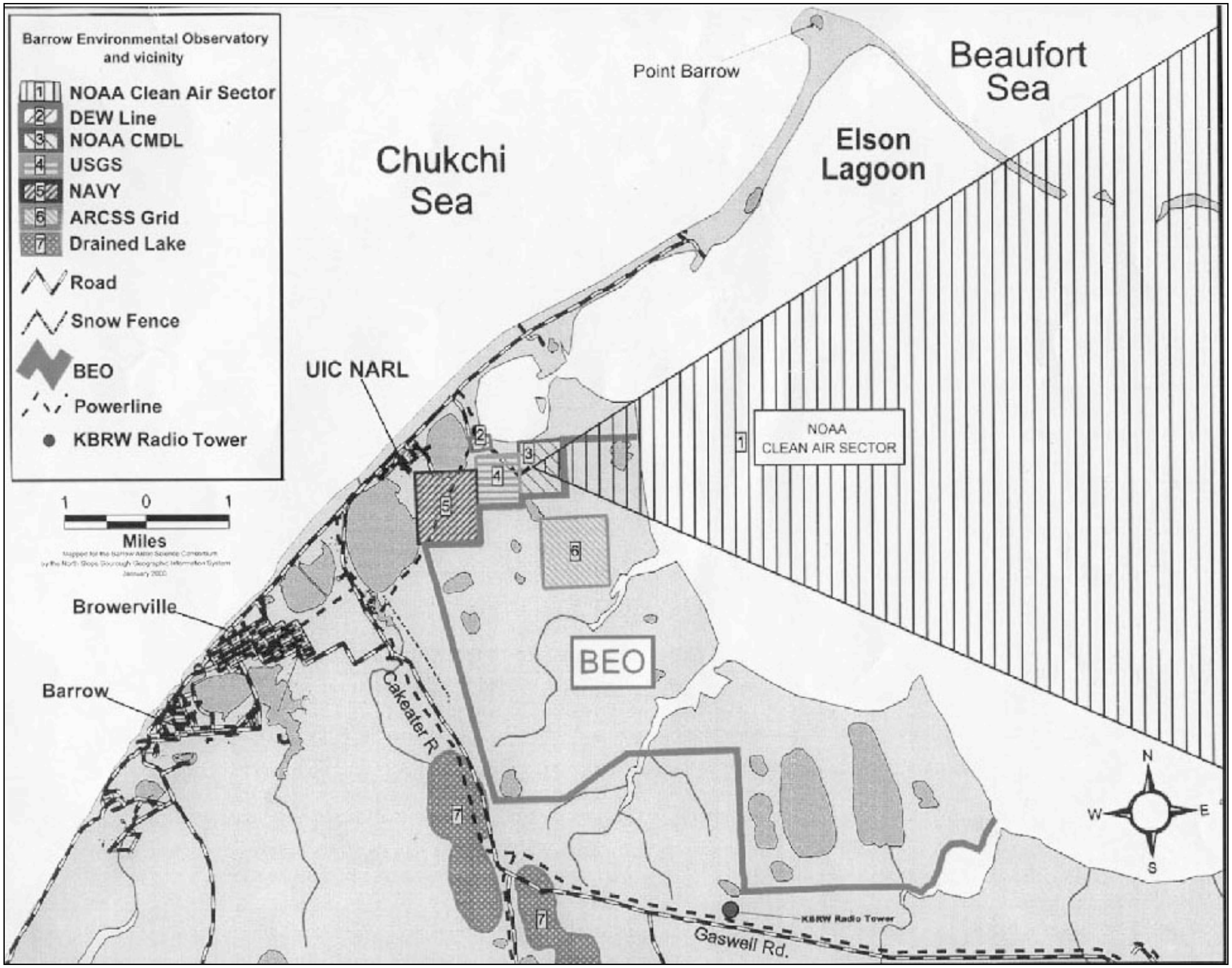

Figure 1: Barrow area showing land ownership, location of UIC-NARL, the Barrow Environmental Observatory, NOAA clean air sector, and roads. (Mapped for BASC by the North Slope Borough Geographic Information System, January 2000)

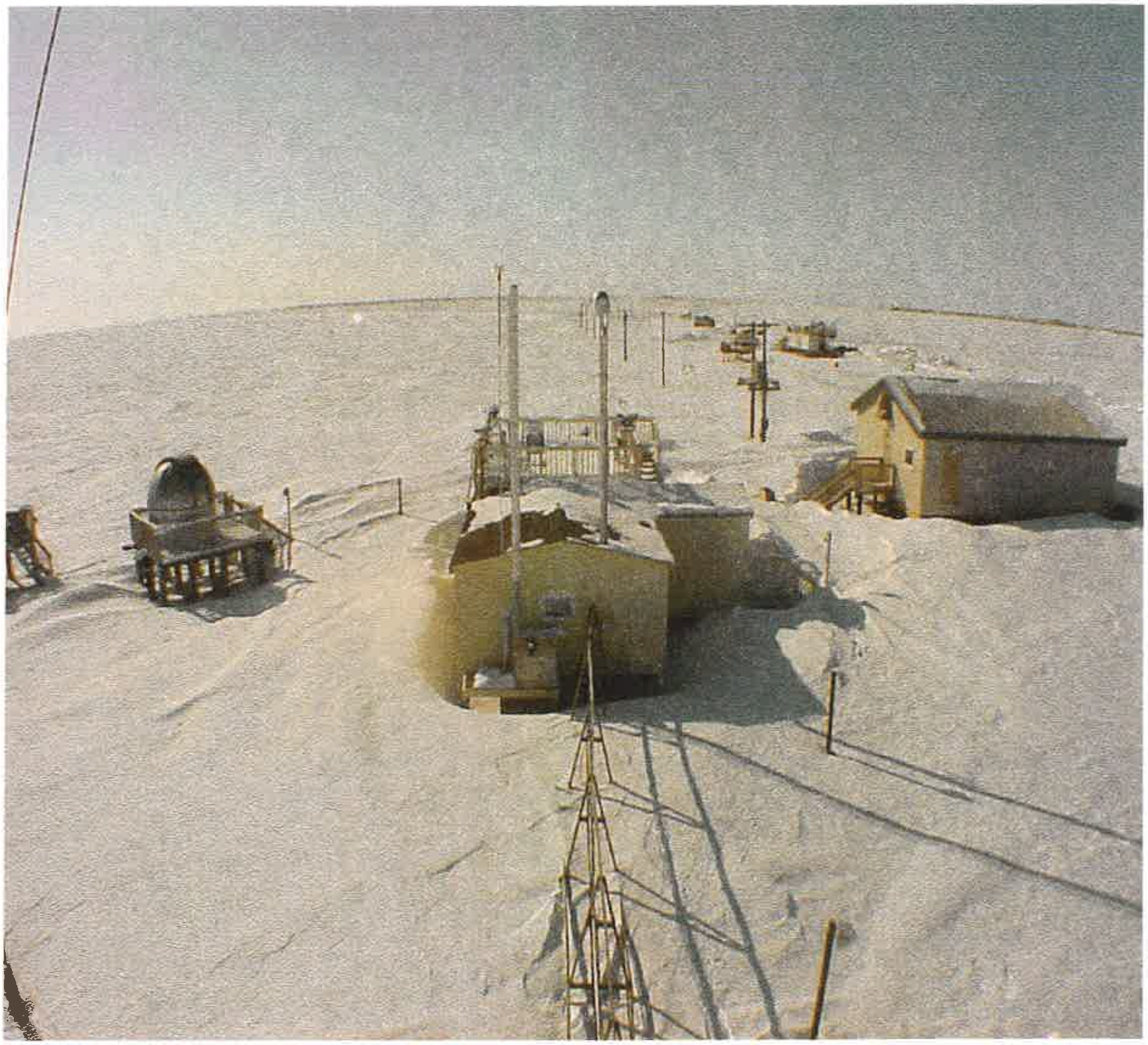

Figure 2. NOAA/CMDL Barrow Atmospheric Baseline Observatory looking westerly from near the base of the 20m sampling tower. The former Naval Arctic Research Laboratory (NARL) facility is on the upper right horizon. The DOE ARM facilities are above and to the left of the garage (center-right) with the USGS Magnetic Observatory above and left of the white DOE building. The Barrow Observatory laboratory is in the center of the view and the Dobson ozone spectrophotometer dome is at center left. Winds persistently blow from the point of the photograph towards the main observatory building. The new NOAA/CMDL main building would be located to the right of the present building and the garage and be connected to both structures with covered walkways. The old laboratory building would be kept as a storage, instrument packing, program staging and cooperative program area requiring heavy pumps and large foot prints.

Inside the Barrow Observatory, the equipment is laid out in an efficient manner but there is little space for movement around the instruments and no space for new instruments. The observatory becomes cramped when more than two people are in the building at one time. The plywood walls are covered with blue packing box foam to reduce the sound from many pumps and instrument motors. The electrical wiring is outdated and insufficient for the requirements being put upon it.

Figure 3. The station chief has his office and work desk in one corner (left photo) and the electrical technician has space in the other corner (right photo) of the wall facing the observatory instrumentation. Both spaces are cramped. Equipment storage cabinets form a divider in the 800ft^2 facility. There are no toilet facilities in the observatory. The Barrow Observatory does not have any other office space here or in the staff quarters that are a partitioned, double-wide trailer with 400 ft^2 of living space for each person.

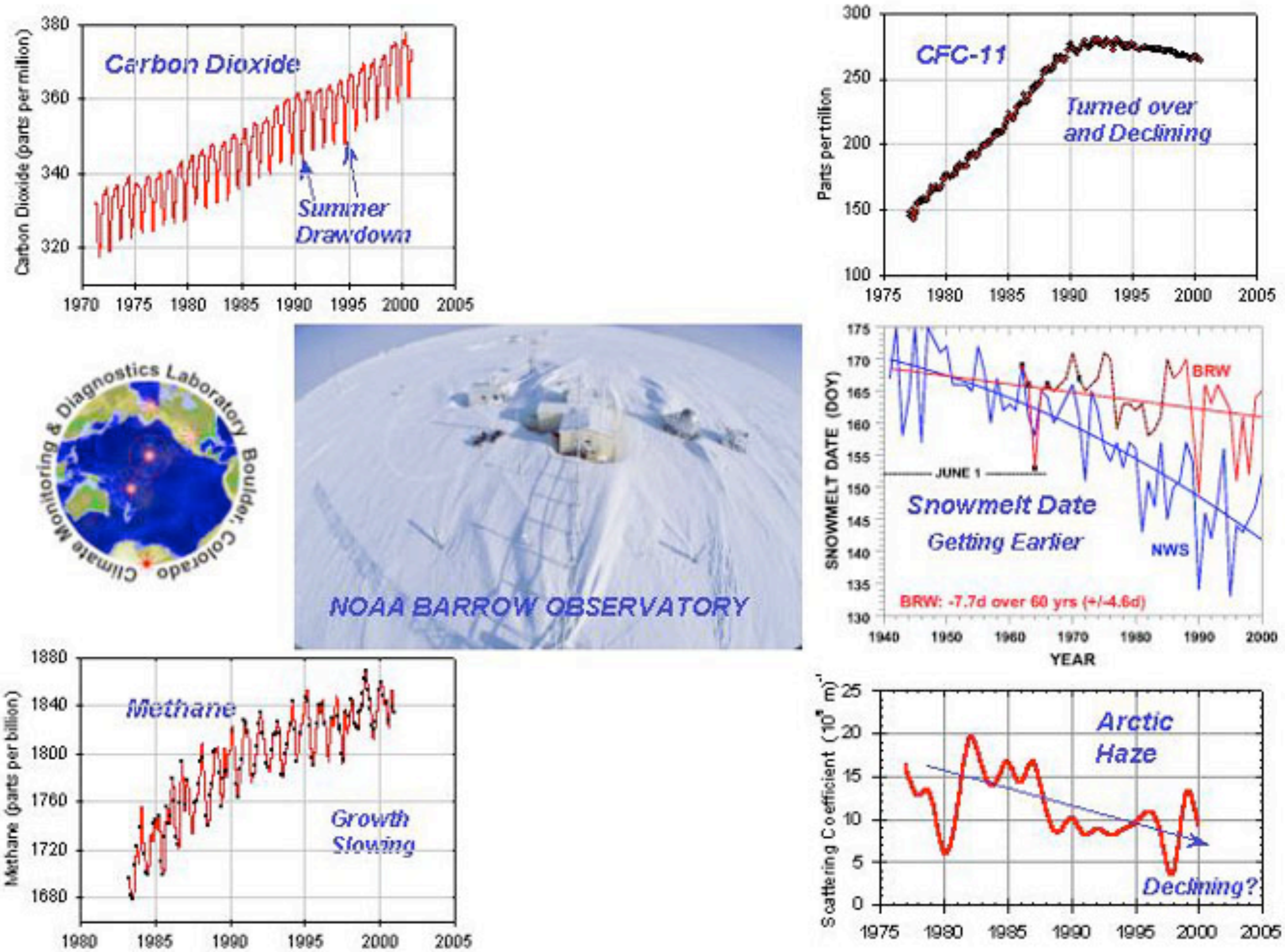

Figure 4: Photo of the NOAA/CMDL Barrow Observatory and data collected at the station.

TABLE 1. **BASC 2002 Projects List (as of 2/22/02)**

NSF Funded Projects

1. **PI:** Jack Kruse and Brad Griffith (OPP-9909156 & OPP-0071082)
   Titles: Sustainability of Arctic communities: Advancing the Science of Integrated Assessment
   Survey Of Living Conditions in the Arctic

2. **PI:** Dr. Dave Cole (OPP-9813221)
   Title: Studies of Microstructural Features and Brine Drainage Networks in First-Year Sea Ice. A Collaborative Project with Dr. Lewis H. Shapiro and Dr. Hajo Eicken, Geophysical Institute, University of Alaska, Fairbanks, Alaska.

3. **PI:** Dr. Judith Curry (OPP-9910297)
   Title: Applications of Aerosondes to Long-Term Measurements of the Atmosphere and Sea Ice in the Beaufort/Chukchi Sector of the Arctic Ocean.

4. **PI:** Dr. Hajo Eicken (OPP-9817738)
   Title: Collaborative Research: Geophysical Constraints on Sea-Ice Bacteria: Implications for Life on Ice-Covered Solar Bodies (supported through Life in Extreme Environments, LExEn Program).

5. **PI:** Dr. Wendy Eisner (OPP-9911122)
   Title: Collaborative Research: Preliminary Investigation of Paleoenvironment, Processes, and Carbon Stocks of Drained Thaw-Lake Basins, Arctic Coastal Plain, Alaska.

6. **PI:** Dr. Jesse Ford (OPP-9979695)
   Title: Sources of Organochlorine Contaminants in Inland Subsistence Fisheries in Northern Alaska: Atmospheric vs. Anadromous Inputs.

7. **PI**: Dr. Tom Grenfell (OPP-9910300)
   Title: Collaborative Research on Long-Term Observations of the Energy and Mass Balance of Coastal Ice Covers in Northern Alaska.

8. **PI:** Dr. Ken Hinkel (OPP-9732051)
   Title: Response of the Global Active Layer-Permafrost System to Climate: CALM- The circumpolar Active Layer Monitoring Program.

9. **PI:** Dr. Ken Hinkel (OPP-9529783)
   Title: Detection of Heat and Moisture Movement in the Upper Permafrost, Northern Alaska.

10. **PI:** Ms. Anne Jensen (OPP-0085248)
    Title: Emergency Archaeological Survey of Nuvuk Area, Point Barrow, AK.

11. **PI:** Dr. Walt Oechel (OPP-9732105)
    Title: Regional Variability in Carbon and Energy Fluxes: Towards a Global Synthesis.

12. **PI:** Dr. Walt Oechel (DGE-9979741)
    Title: PISCES Project: Ipalook Elementary School, Barrow AK.

13. **PI:** Dr. Patrick Webber (OPP-9714103)
    Title: Response of Arctic Tundra to Variation of Temperature (ITEX).

14. **PI:** Dr. Patrick Webber (OPP-9906692)
    Title: Forecasting Arctic Vegetation (FAV)

15. **PI:** Dr. Frederick Nelson (OPP-0094769)
Title: Collaborative Research: Spatial And Temporal Variability Of Ground Temperature And Thaw, Northern Alaska.

16. **PI:** Dr. Steven Oberbauer (OPP-9907185)
Title: Collaborative research: Species Responses To Changes In Climate Across Arctic Gradients Using The ITEX Network (NATEX): Influences On Community And Ecosystem.

17. **PI:** Dr. James Bockheim
Title: Collaborative Research: Preliminary Investigation of Paleoenvironment, Processes, and Carbon Stocks of Drained Thaw-Lake Basins, Arctic Coastal Plain, Alaska.

18. **PI.** Dr. Dave Norton (OPP-9908682)
Title: Synthesis Approach To Link Remote-sensing Information With Natural History And Traditional Knowledge Through Case Studies Of Unusual Sea Ice Conditions.

19. **PI.** Dr. Amanda Lynch (OPP-0100120
Title: An Integrated Assessment Of The Impacts Of Climate Variability On The Alaskan North Slope Coastal Region).

20. **PI.** Dr. John Wingfield (OPP-9911333)
Title: High Latitude Breeding.

21. **PI.** Dr. Jerry Brown
Title: Barrow Permafrost Observatory (NSF & IARC funded: Project 3.1)

22. **PI.** Dr. Chien-Lu Ping (OPP-9732731)
University of Alaska, Fairbanks
Title: Winter C-Flux

23. **PI:** Dr. George Divoky (IARC funded)
Title: EPSCoR Involvement in Dr. Divoky's project: Black Guillemot, Climate and contamination in the Western Arctic.

24. **PI:** Dr. Matthew Sturm
Title: Snow, Weather, And Shrubs: Winter Pathways Of Change In The Arctic.
Note:

25. **PI:** Dr. Carin Ashjian
Title: Biocomplexity-Incubation Activity: How Physical-Biological Coupling In The Western Arctic Ocean Influences Marine Mammal abundance And Native Subsistence Harvests.

26. **PI:** Mr. Robert Suydam
Title: Teachers Experiencing The Arctic (TEA) program. TEA, Kim Hanisch, will participate in Mr. Suydam's non-NSF funded project called, Breeding biology Of King Eiders And Other Waterfowl In The Vicinity Of Teshekpuk Lake, Alaska.

27. **PI:** Dr. Roland Gangloff (GEO-0121972)
Title: Geosciences In Alaska Field Explorations and Research For K-12 Teachers

28. **PI:** Dr. George Happ
Title: Alaska EPSCoR/BASC/Barrow High School Memorandum Of Agreement
(Ongoing in Barrow High School during school year and individual research projects intermittently throughout calendar year)

29. **PI:** Dr. John Hobbie
Title: Toolik Lake LTER Schoolyard Educational Project

30. **PI:** G. Bernard
Title: UV Monitoring

31. **PI:** Dr. David Kadko
Title: Collaborative Research: Radiometric Dating Of Whale Bones – A Tool For Study Of Succession And Persistence Of Whale Fall Chemoautotrophic Assemblages

TABLE 2. **Toolik Field Station 2002 Projects List (as of 4/15/02)**

NSF Funded Projects

1. **PI:** Brian Barnes and John Duman (OPP-0117104 & OPP-0004446)
   Title: Collaborative Research: Studies of Antifreeze Proteins in Arctic and Neararctic Insects

2. **PI:** Brian Barnes (OPP-9819540)
   Title: Energetics, Homeostasis, and Life History in an Arctic Hibernator

3. **PI:** F. Stuart Chapin (OPP-9732126)
   Title: Transitions: A Study of the Spatial and Temporal Transition of Climate and Ecosystems in the Circumpolar Arctic

4. **PI:** Yu-Ping Chin and Diane McKnight (OPP-0097142 & OPP-0095137)
   Title: Collaborative Research: The Direct and Indirect Photolytic Fate of Persistent Organic Pollutants in Arctic Surface Waters

5. **PI:** Daniel F. Doak (OPP-0087078)
   Title: LTER Cross-site: Collaborative Research - Assessing the Geographic and Temporal Consistency of Life History and Demographic Patterns: A Long-term, Multi-site Comparison

6. **PI:** William Fitzgerald (OPP-9908895)
   Title: Mercury Contamination and Biogeochemical Cycling in the Arctic

7. **PI:** Laura Gough and Sarah Hobbie (OPP-9902721 & OPP-9902695)
   Title: Collaborative Research: Moist Acidic vs. Non-Acidic Tundra: Why Does the Vegetation Composition Differ and What are the Consequences for Ecosystem Carbon Storage?

8. **PI:** Anne Hershey (OPP-0090202)
   Title: RUI: A Geomorphic-Trophic Hypothesis for Arctic Lake Productivity

9. **PI:** Kenneth Hinkel (OPP-9732051)
   Title: Response of the Global Active Layer-Permafrost System to Climate: CALM - the Circumpolar Active Layer Monitoring Program

10. **PI:** Kenneth Hinkel and Frederick Nelson (OPP-0094769 & OPP-0095088)
    Title: Collaborative Research: Spatial and Temporal Variability of Ground Temperature and Thaw, Northern Alaska

11. **PI:** Larry D. Hinzman (OPP-9818066)
    Title: Hydrologic Response and Feedbacks to a Warmer Climate in Arctic Regions

12. **PI:** John E. Hobbie (OPP-9615949)
    Title: Key Connections in Arctic Aquatic Landscapes

13. **PI:** John Hobbie (OPP-9911278)
    Title: Aquatic Ecosystem Responses to Changes in the Environment of an Arctic Drainage Basin

14. **PI:** John Hobbie (OPP-9810222)
    Title: LTER: The Arctic LTER Project: The Future Characteristics of Arctic Communities, Ecosystems, and Landscapes

15. **PI:** John Hobbie (OPP-9732281)
Title: The Response of Carbon Cycling in Arctic Ecosystems to Global Change: Regional and Pan-Arctic Assessments

16. **PI:** Douglas Kane (OPP-9814984)
Title: Temporal Variation of Hydrology in the Alaskan Arctic

17. **PI:** Sally MacIntyre (OPP-0108572)
Title: Turbulent Mixing, Internal Waves, and Intrusions: Effects on Resource Supply and Primary Productivity in Lakes

18. **PI:** Knute Nadelhoffer (OPP-9911681)
Title: Developing Process-Level Understanding of Controls on Belowground Carbon and Nutrient Dynamics in Tundra Ecosystems

19. **PI:** Frederick E. Nelson (OPP-9907534)
Title: Collaborative Research: Stochastic Variability of Seasonal Freezing and Thawing at Local, Regional and Hemispheric Scales Under Modern and Predicted Climate

20. **PI:** Steven Oberbauer (OPP-9907185)
Title: Collaborative: Species Responses To Changes In Climate Across Arctic Gradients Using The North American ITEX Network (NATEX): Influences on Community and Ecosystem Processes

21. **PI:** Chien-Lu Ping (OPP-9732731)
Title: Winter C-Flux in Arctic Ecosystems Under Changing Climate: Effects of Soil Carbon and Active Layer Dynamics

22. **PI:** Edward B. Rastetter (OPP-0108960)
Title: Species-, Community-, and Ecosystem-Level Consequences of the Interactions Among Multiple Resources

23. **PI:** Vladimir E. Romanovsky (OPP-9870635)
Title: Influence of Climate and Environmental Factors on the Thermal and Moisture Regimes of the Layer and Permafrost

24. **PI:** Joshua Schimel (OPP-9731999)
Title: Winter C-Flux in Arctic Ecosystems Under Changing Climate: Effects of Soil Carbon and Active Layer Dynamics

25. **PI:** Gaius Shaver (OPP-0096523)
Title: Primary Production in Arctic Ecosystems: Interacting Mechanisms of Response to Climate Change

26. **PI:** Gaius Shaver (OPP-0087046)
Title: LTER Cross-Site: Interactions between Climate and Nutrient Cycling in Arctic and Subarctic Tundras

27. **PI:** Gaius Shaver (OPP-0089585)
Title: Turnover and Retention of Nitrogen in an Arctic Watershed: Links to Organic Matter Accumulation and Response to Climate

28. **PI:** Marc Stieglitz (OPP-0002369)
Title: Collaborative Research: Modeling Hydrologic Processes in the Arctic: A Watershed Approach for Regional and Global Climate Models

29. **PI:** Matthew Sturm (OPP-9732077)
Title: Collaborative Research: Snow, Weather and Shrubs: Winter Pathways of Change in the Arctic

30. **PI:** Bjartmar Sveinbjornsson (OPP-9978143)
Title: Arctic and Alpine Treelines in Alaska: Controls on Performance of White Spruce - Implications for Global Change

31. **PI:** Donald A. Walker (OPP-9908829)
Title: Arctic Climate Change, Substrate, and Vegetation

32. **PI:** Marilyn Walker (OPP-9907127)
Title: Collaborative: Species Responses to Changes in Climate Across Arctic Gradients using the North America ITEX Network (NATEX): Influences on Community and Ecosystem Processes

33. **PI:** Jeffrey Welker (OPP-9907356)
Title: Collaborative Research: Species Responses to Changes In Climate Across Arctic Gradients Using the INTEX Network (NATEX): Influences On Community and Ecosystem Processes

34. **PI:** Patrick J. Webber (OPP-9906692)
Title: Forecasting Arctic Vegetation: The Interaction Between Surface Disturbance and Climate Change

35. **PI:** Jeffrey M. Welker (OPP-9617643)
Title: Comparative Responses of Moist and Dry Arctic Tundra to Altered Snow Temperature Regimes

36. **PI:** John Wingfield (OPP-9911333)
Title: High Latitude Breeding

37. **PI:** John C. Wingfield (OPP-9905679)
Title: Control of Reproduction in Diverse Habitats

38. **PI:** Laura Broughton (OPP-0102108)
Title: Postdoctoral Research Fellowships in Microbial Biology for FY2001

39. **PI:** Gretchen Gettel (OPP-0206173)
Title: Dissertation Research: Why Does N-Limitation Occur in Some Arctic Lakes? Understanding Controls of N-Fixation

TABLE 3. **Summary of Measurement Programs at the Barrow Observatory**

Program/Measurement	Instrument	Sampling Frequency
Gases		
CO_2	Siemens Ultramat 5E analyzer	Continuous
	3-L glass flasks	1 pair wk^{-1}
	0.5-L glass flasks, through analyzer	1 pair wk^{-1}
CO_2, CH_4, CO, and $^{13}C/^{12}C$ and $^{18}O/^{16}O$ of CO_2	0.5-L glass flasks, P^3 pump unit	1 pair wk^{-1}
CH_4	Carle automated GC	1 sample $(12\ min)^{-1}$
Surface O_3	Dasibi ozone meter	Continuous
Total O_3	Dobson spectrophotometer no. 91	3 day^{-1}
CO_2	Siemens Ultramat 5E analyzer	Continuous
N_2O, CFC-11, CFC-12, CFC-113, CH_3CCl_3, CCl_4	300-mL stainless steel flasks	1 sample mo^{-1}
N_2O, CFC-11, CFC-12, CFC-113, CH_3CCl_3, CCl_4, SF_6, HCFC-22, HCFC-141b, HCFC-142b, CH_3Br, CH_3Cl, CH_2Cl_2, $CHCl_3$, C_2HCl_3, C_2Cl_4, H-1301, H-1211, H-2402, HFC-134a	850-mL stainless steel flasks	1 sample mo^{-1}
CFC-11, CFC-12, CFC-113, N_2O CCl_4, CH_3CCl_3	HP5890 automated GC	1 sample h^{-1}
N_2O	Shimadzu automated GC	1 sample h^{-1}
CO	Trace Analytical GC	1 sample $(6\ min)^{-1}$
CFC-11, CFC-12, CFC-113, N_2O, CH_3CCl_3, CCl_4 CH_3Br, CH_3Cl, H-1211, SF_6	Automated CATS GC	1 sample h^{-1}
Aerosols		
Condensation nuclei	Pollak CNC	1 day^{-1}
	T.S.I. CNC	Continuous
Optical properties	Four-wavelength nephelometer	Continuous
Black carbon	Aethalometer	Continuous
Solar Radiation		
Global irradiance	Eppley pyranometers with Q and RG8 filters	Continuous
Direct irradiance	Tracking NIP	Continuous
	Eppley pyrheliometer with Q, OG1, RG2, and RG8 filters	Discrete
Albedo	Eppley pyranometer	Continuous
Ultraviolet B irradiance	NILU radiometer	Continuous
Ultraviolet B irradiance	Yankee-UVB radiometer	Continuous
Ultraviolet spectral irradiance	Biospherical five-wavelength photometer	Continuous
Aerosol optical depth	Carter-Scott four-wavelength sunphotometer	Continuous
Terrestrial (IR) Radiation		
Upwelling and downwelling	Eppley pyrgeometers	Continuous
Meteorology		
Air temperature	Thermistor, 2 levels	Continuous
	Max.-min. thermometers	1 day^{-1}
Dewpoint temperature	Dewpoint hygrometer	Continuous
Pressure	Capacitance transducer	Continuous
	Mercurial barometer	Discrete
Wind (speed and direction)	R.M. Young Aerovane	Continuous
Precipitation	Rain gauge, tipping bucket	Continuous

TABLE 4. **CMDL Cooperative programs prior to 2001**

Program/Measurement	Instrument	Sampling Frequency
Cooperative Programs 2000-2001		
Total surface particulates (DOE)	High-volume sampler (1 filter wk^{-1})	Continuous
Precipitation gauge (USDA)	Nipher shield, Alter shield, 2 buckets	1 mo^{-1}
Magnetic fields (USGS)	3-Component fluxgate magnetometer and total field proton magnetometer	Continuous
	Declination/inclination magnetometer sample	6 sets mo^{-1}
CO_2, ^{13}C, N_2O (SIO)	5-L evacuated glass flasks	1 set wk^{-1} (3 flasks set^{-1})
CH_4 (Univ. of Calif., Irvine)	Stainless steel flasks	1 pair wk^{-1}
O_2 in air (Princeton)	3-L glass flasks	1 set $(3\ mo)^{-1}$
CO_2 flux (San Diego State Univ.)	CO_2 and H_2O infrared gas analyzer and sonic anemometer	Continuous, check site 1 wk^{-1}
Magnetic fields (NAVSWC)	^3He sensors	$1\ (2\ wk)^{-1}$
Magnetic micropulsations (Univ. of Tokyo)	Magnetometer and cassette recorder	$1\ (3\ wk)^{-1}$
UV monitor (NSF)	UV spectrometer	1 scan per 0.5 hour
Study thaw depth in permafrost (SUNY)	Temperature probe	Continuous
Total VOC and heavy metals (Hokkaido Univ.)	Filter samples	1 h^{-1}

TABLE 5. **CMDL Cooperative programs added in 2001 or approved for 2002**

In operation		
Atmospheric mercury (EPA, NOAA ARL)	Mercury vapor monitors	Continuous
Arctic coastal ice characteristics (Univ. Washington, Seattle)	Optical sensors	Continuous
POES satellite transmission downlink (NESDIS)	3-m dish and receiver	Continuous
Soil organic matter (Univ. of Alaska, Fairbanks)	Vegetation sampling	Discrete samples
Organochlorine contaminants (Oregon State Univ.)	Air samples	Discrete weekly measurements
Snow radiation (JMA and MRI, Japan)	Albedo and reflections form snow	Continuous
Eider duck migration patterns (Univ. of Alaska, Fairbanks)	Radar and Optical Observations	Seasonal
Mercury in snow (EPA and BASC)	Snow samples	Winter season
Approved for 2002		
Optical properties of Arctic ecosystems (Cal. State Univ.)	Multi-spectral optical sensors	Continuous
SuomiNet GPS meteorology station (Univ. of Alaska, Fairbanks)	GPS water vapor measuring station	Continuous
Removal mechanisms of Arctic Haze (Wayne State Univ.)	Aerosol samples	Continuous samples, weekly filter change
NOAA Climate Reference Station (NOAA)	Global Climate Reference Station	Continuous
DMS measurements (Univ. of Alaska, Fairbanks)	DMS denuders and gas analyzer	Continuous
Trace gas intercomparisons (Univ. of Alaska, Fairbanks)	CO_2 and CH_4 sensors	Continuous

References:

Arctic Science in the Barrow Region: Recommendations for Future Facilities. 2002. Barrow Arctic Science Consortium (BASC). Barrow, Alaska.

The Future of an Arctic Resource: Recommendations from the Barrow Area Research Support Workshop. 1999. Arctic Research Consortium of the U.S. (ARCUS). Fairbanks, Alaska.

Logistics Recommendations for an Improved U.S. Arctic Research Capability. Arctic Research Consortium of the U.S. (ARCUS). Fairbanks, Alaska, July 1997. 88 pp.