Brookhaven National Laboratory

Fire in the Debris Soil Pile DST-2, Chemical and Glass Holes Project: The Investigation Report

March 11, 2000

BROOKHAVEN NATIONAL LABORATORY

Brookhaven National Laboratory managed by Brookhaven Science Associates, LLC

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At

Brookhaven National Laboratory

Upton, New York

March 11, 2000

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I. Scope

On Saturday March 11, 2000 a fire occurred in the DST-2 Debris Pile of the Chemical and Glass Holes Project at Brookhaven National Laboratory (BNL).

An internal investigation committee was appointed by Brookhaven National Laboratory's Assistant Laboratory Director of Environmental Management (see Appendix A). The committee was asked to determine the cause of the fire, evaluate the response actions taken, and recommend corrective actions to prevent a similar fire from occurring in the future. The scope of work specifically included personnel, equipment, and procedures leading up to the incident, and the systems used to mitigate the consequence of the fire.

This report follows Brookhaven National Laboratory's (BNL) Subject Area on the Investigation of Incidents, Accidents, and Injuries, and the DOE's guidelines for investigating accidents. The Accident Investigation Panel used various analytical techniques, including accident analysis, barrier analysis, and causal factor analysis. The Panel interviewed personnel involved in the Chemical/Glass Holes Project (see Appendix B). The Panel also inspected the accident scene, events relating to the accident, and documents to determine the factors that contributed to the accident (See Appendix C).

II. Executive Summary

Incident

On March 11, 2000, a fire occurred at a waste-staging area associated with the Chemical/Glass Holes Project at Brookhaven National Laboratory. The waste included low level radioactive soil and processed (shredded) debris which was stored in “Soft Sided Lift Liner” containers. Thirty-two lift liner containers, made of light density polypropylene, containing these wastes were involved in the fire. The plastic lift liner containers and the polyethylene coverings were the primary fuel. The plastic sacks most likely were ignited by burning pieces of straw. The warm spring day in March accelerated bacterial action within the straw, generating sufficient heat to spontaneously combust. Combustible straw had been allowed to enter the waste stream without its hazards being identified and controls implemented.

In a previous fire at the Chemical/Glass Holes Project during the fall of 1999, a steel tube containing 2- to 3-pounds of reactive metals entered the waste stream and ignited shredded personnel-protective-equipment in the shredder’s collection bag. At that time, reactive metals were thought to have been removed, the hazard had not been identified, and precautions were not in place.

The emergency response was appropriate and effective. On-scene monitoring, air sampling, and post-accident sampling did not indicate any releases above background levels to air, soil or surface water.

Direct property loss (sacks, polyethylene cover) is estimated at under $17,200. The costs of the repackaging and analysis were $10,000. Investigation costs are estimated at $10,000. The cost of emergency response (Radiological Control Technician, Fire/Rescue, and Analytical Services) is estimated at $33,000.

Causal Factors

- The direct cause of the fire was the ignition by bacterial action of pieces of a bale of straw, which eventually involved the plastic lift liners and plastic UV covering.
- The root cause was the failure of the project staff to recognize the fire hazard associated with spontaneous combustion of baled straw, and the combustibility of the lift liner/cover system.
- The systemic root-cause was the failure to properly identify new hazards, implement the proper level of controls for changes incurred in the project, and incorporate safety related feedback from previous project activities.

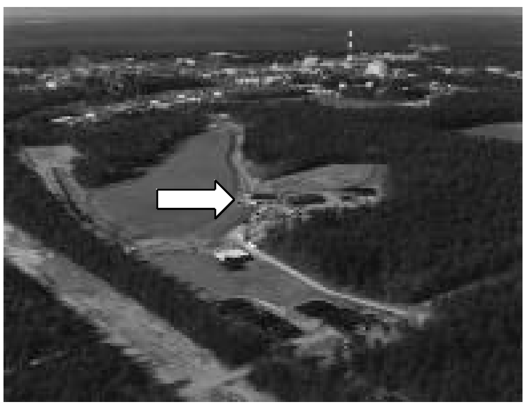
Conclusions and Judgement of Needs

Conclusions	Judgement of Needs
The emergency response to the incident was effective. Additional pre-fire information on hazards information would have assisted the first responders with evaluation. Lessons-learned from the October 1999 fire could have provided guidance on improving pre-fire planning. Radiological and hazardous materials were not released from the fire. The fire burned the majority of the combustibles on the surface of the pile; this outcome represents a worst-case fire and a worst-case release scenario. A pre-fire evaluation might have determined this maximum release scenario and avoided having to declare a Base Operational Emergency.	There is a need to have pre-fire plan information for operations that are not associated with a building.
Straw within the debris piles was ignited by spontaneous combustion. The rains before the shredding of the bales, the high spring temperatures, and "solar heating" of the black HPDE covering provided the correct conditions for increasing bacterial action. The fire hazard from the plastic lift liner was not considered in the DOE evaluation of the lift liner system. Therefore, the Project's internal decisions did not identify this as an issue. Consequently, there were no controls to address combustible materials. The Project did not have an adequate feedback process to incorporate lessons-learned from other fires elsewhere at BNL. Lessons learned from earlier fires involving bales of straw could have flagged the hazards. The lessons-learned from the Project's October fire could have provided controls to manage the fire risks of combustible materials. Soils were recommended for padding the lift liner system. Internal reviews that evaluated alternative padding methods to avoid punctures of the lift liners did not identify the risks of shredded combustible materials or bales of straw.	There is a need to review management controls and systems for assessing and controlling the hazards of the facility operations. There is a need to improve the level of review so important activities and equipment can be defined, and controls developed and implemented. DOE should be notified of the issues on the combustibility of the lift liner system.
It could not be determined if there were other bales of straw in the three remaining piles of debris. The fire began many hours before its discovery.	There is a need to develop a plan to deal with the hazards associated with the remaining piles of debris potentially containing bales of straw.

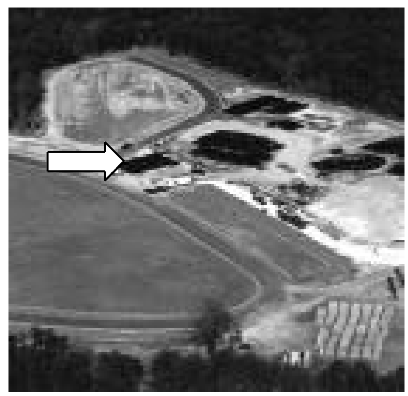
III. Facts

A. Site Description

Brookhaven National Laboratory is located in Suffolk County, New York, 60 miles east of New York City on Long Island. The 5,500-acre property has approximately 500 developed acres. Just to the south east of the central section of buildings is a section of land used during the 1950s and 1960s for waste disposal. In addition to municipal waste disposed of in conventional landfills, 55 "Chemical/Glass Holes" were dug over time to dispose of laboratory wastes. Twenty to thirty five-foot-deep holes were dug, as needed to accommodate the daily disposal of materials. Dirt was used for a cover between disposal cycles and as a final cover. The materials excavated from the Chemical/Glass Holes were the source of the debris involved in this incident.



Aerial view of Project.
View looking Northwest toward center of site.
Arrow points to DTS-2 pile.



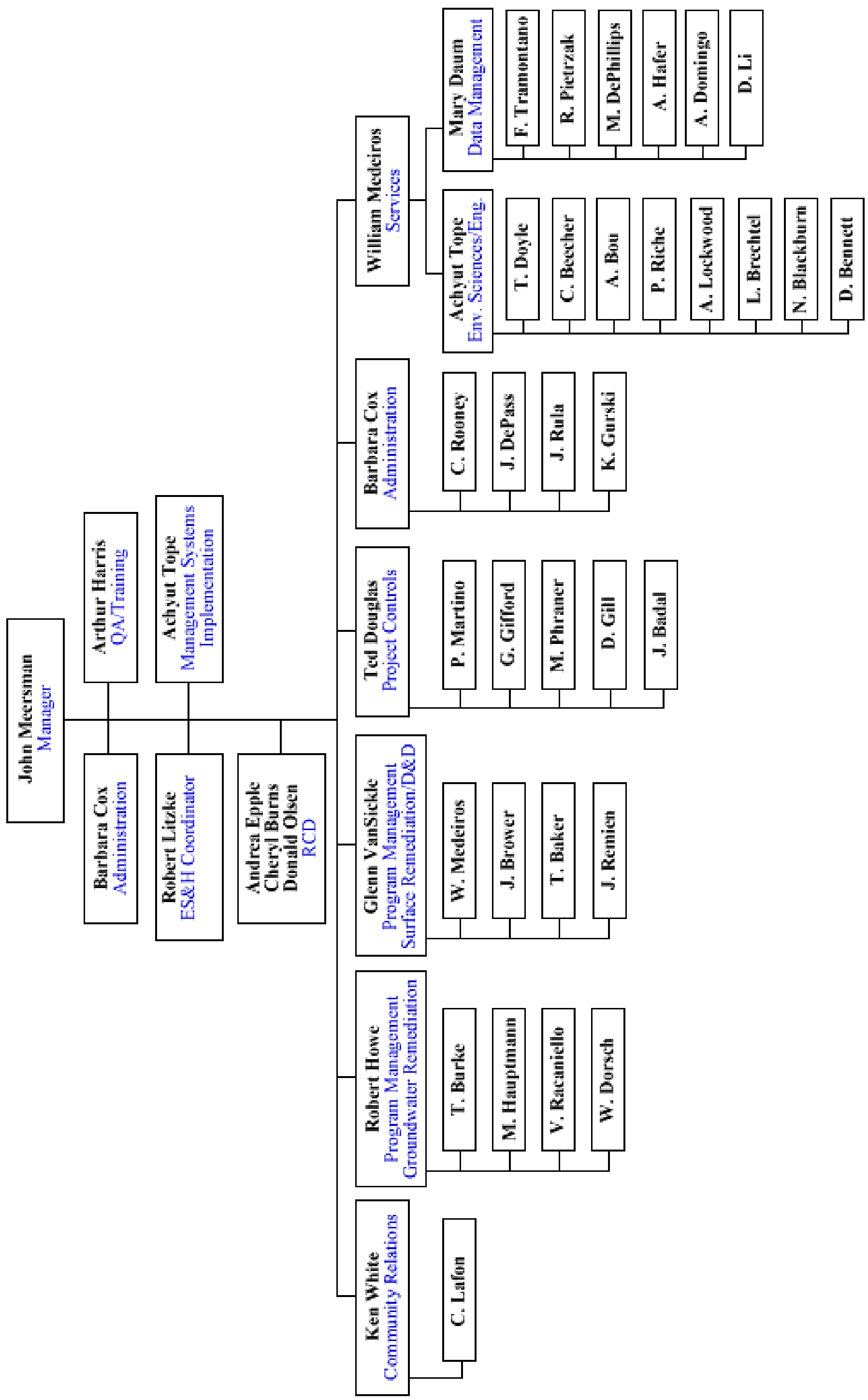
Close-up of aerial view.

During 1997, the 55 Chemical Holes at BNL were excavated, the materials sorted, and then stored pending characterization and packaging for shipment.

The Environmental Restoration Division (ERD) of BNL was assigned the project (see organization chart shown in following figure). Project management was conducted from the Program Management Surface Remediation Section of ERD. Field services were conducted by the Environmental Services Engineering Section.

The excavated materials were placed on a conveyor system where technicians removed various wastes including bottled liquids, bottled solids, intact cylinders/vessels, bio-wastes, and radiological wastes. The remaining material (soil/debris) was directed to a 2 inch screen; material that passed through the screen was stockpiled as soil, and the remaining rock/debris was stockpiled as debris. The stockpiled material was placed on and covered with 20 mil thick high density polypropylene (HDPE). The stockpiles used approximately 20 straw bales to prevent the runoff of soil. The removal was completed by the end of September 1997.

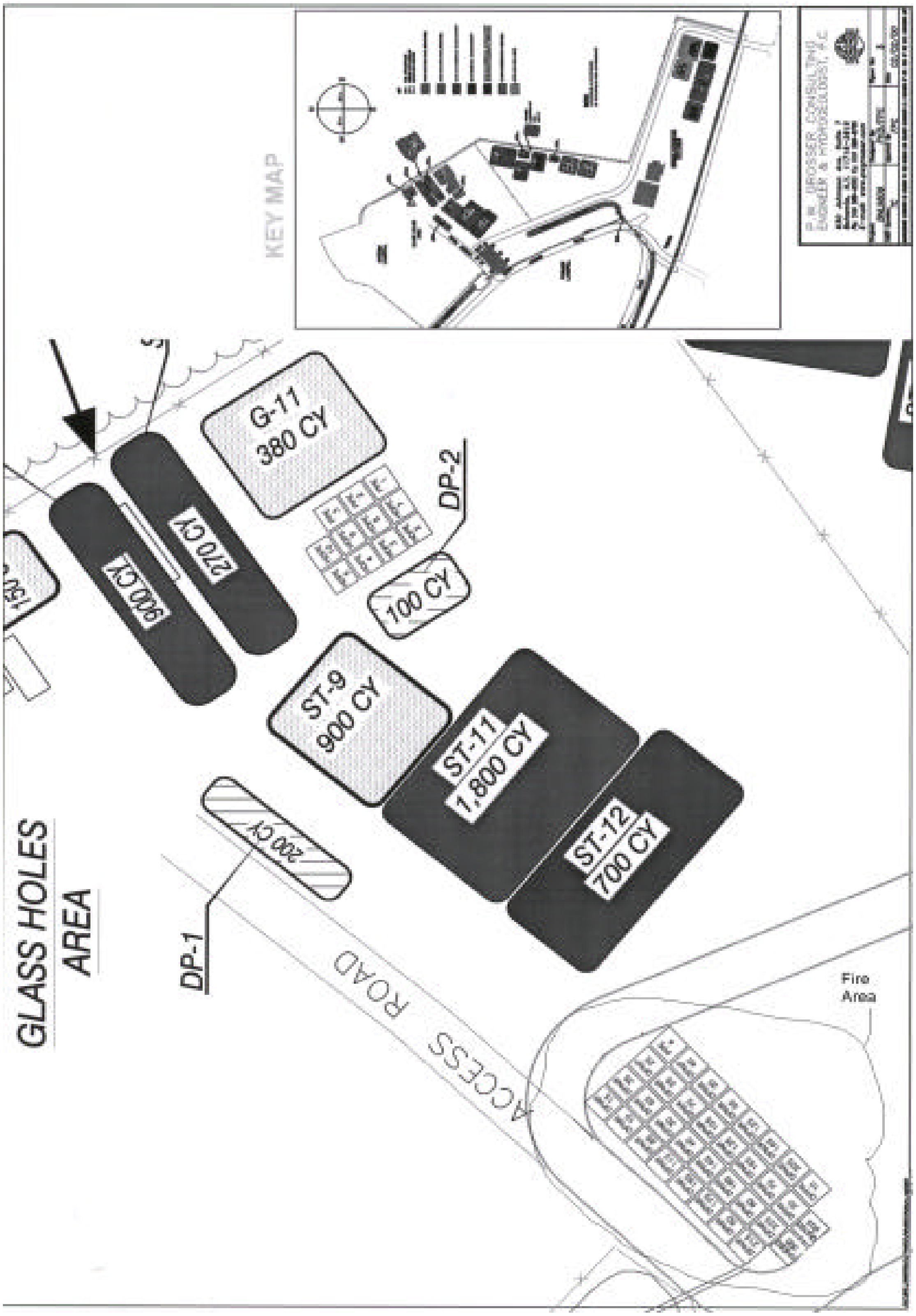
Environmental Restoration Division Organization Chart



In the fall of 1998, planning for the characterization of the debris stockpiles had begun. An evaluation of alternative methods for characterization was prepared and reviewed by BNL and the DOE. The alternative chosen was to visually inspect the debris, segregating the non-conforming material, and then to shred it. The shredded debris was then characterized using standard sampling techniques.

From January to August 1999, a Work Plan and a Safety & Health Plan was developed for the final sorting, shredding, and packaging. The plans were reviewed by Environmental Restoration Division, Radiological Controls Division, Environmental Safety & Health Services Division, Waste Management Division, and the DOE. The operation ended in the October 1999.

Assorted materials removed from Chemical/Glass Holes after 1997 sorting operation.



Plan view of the area with DST-2 in the lower right corner.
South is left and North is right.

B. Waste Packaging

The wastes were packaged for storage and eventual shipment in a soft-sided lift liner system. The system consists of an exterior woven polyethylene fabric, 20 mils thick, coated with a 2 mil thick water resistance coating (details unknown) and an interior woven liner of two layers of polyethylene, 45-mils thick. The lifting system is fitted with straps to enclose the top opening. Additional straps provide support for hoisting, using a special rigging fixture. The system was developed and demonstrated at Idaho National Engineering and Environmental Laboratory in March 1999. The "Soft Sided Waste Container System" is attractive due to the low cost of the container, ease of filling, and ease of packing for overland transport (compared to metal containers, B-25 and B-52 types).

The DOE report evaluating the soft-sided container product commented on its safety, risks, and benefits. The Innovative Technology Report states that the safety issues are primarily hazards from heavy equipment/construction and radiation. The reports concluded that "In both cases the risks are mitigated by use of proper equipment, monitoring, PPE, training, signs and barriers." There was nothing on combustibility or fire hazards.

To avoid puncturing the lift liner system, the report recommended filling the bottom inches of the liners with soil. By alternating sharp material with soil, additional protection against puncture could be obtained.

Rigging of a soft sided lift liner waste container system, and its placement on plastic liner.

The polypropylene packing materials for the lift liner system used at BNL was manufactured by Transportation Plastics, Incorporated, Sweetwater, Tennessee.

The Material Safety Data Sheet for the product indicates that the plastic has the following physical characteristics:

Material is Polypropylene with Olefin
Melting point: 320°F
Auto-ignition: 735°F

C. Fire Protection

The level of fire protection was reviewed during the original excavations in 1997. During excavation and sorting, fire extinguishers and cell telephones were provided. The nearest fire hydrant is approximately 1/2 mile away, located at the warehouse complex to the west. Before the March fire, there were no routine patrols of the area during non-working hours. Employees are not normally present, except during inspections, maintenance, and rigging operations.

D. Work Planning, Controls, and Feedback for the Final Waste Characterization

A "Health and Safety Plan[1]" and "Debris Characterization Work Plan[2]" were developed by subcontractors for the final waste processing packaging and characterization phase of the project. The documents were reviewed by BNL's Environmental, Health, and Safety Organizations. Comments were forwarded to the project. Appendix D shows the review time line.

Final Health & Safety Plan and Work Plan documents were issued in August 1999. The Health and Safety Plan is an 86-page document, not including appendixes. On August 30 1999, all personnel received training from the subcontractor on the Health and Safety Plan. Training was supplemented by the participants reading the plan and signing an acknowledgement that they understood it. Persons arriving after the initial training received an orientation and were directed to read the Plan and sign the acknowledgement. Procedures for workers were derived from the Plan and put into instructions. Daily safety briefings were held to discuss safety-related issues associated with scheduled work of that day. Thirteen physical and chemical hazards were identified in the Health and Safety Plan, but a fire in the debris piles was not included. The documents had not been revised up to the date of the fire.

The work-planning documents stated that off-site shipments would be in sturdy containers in compliance with Department of Transportation regulations. However, there was no formal review of the use of the soft-sided lift liners. The soft-sided lift liners need to be covered to prevent deterioration from UV light. Black HDPE 20-mil cover was used for this. Reviews were performed internally within the project staff. Review and controls were implemented on an informal basis, normally within the technical and project staff of ERD.

E. Prior Fire Events at the Project

During the initial excavation operation in 1997, several "pockets" of reactive metals (most likely sodium-containing materials) were encountered according to the project's staff. While scraping the pile back with an excavator, sparks were observed. Metal containers were found with "sizzling" materials. The recovered materials were set aside and identified as sodium and liquid sodium potassium (NaK). The sodium metal was put into a single sealed container for later disposal. It was ascertained that the reactive metals could

1 "Health and Safety Plan for the Debris Processing and Characterization Effort at the Chemical Holes Project," prepared for Brookhaven National Laboratory, Upton, New York, BNL Contract No. 7994004-Task Order No. 19, August 1999, Prepared by Environmental Resources Management, 175 Froleich Farm Blvd., Woodbury. New York 11797.

2 "Debris Characterization Work Plan for the Animal/Chemical Pits and Glass Holes," prepared for Brookhaven National Laboratory, Environmental Restoration Division, Upton, New York 11973, August 1999, Prepared by P.W. Grosser Consulting,

be found in small _ inch type tubing (typically with crimped ends) in small stainless-steel vessels, or in glass containers. Waste fitting this general description was isolated for further disposal.

During the fall 1999 waste-processing operation, the debris waste was shredded. Some Tyvek personnel protective equipment was also shredded and used to pad the lift liner system to avoid punctures. During the final treatment of the debris, a piece of metal that contained a reactive metal was inadvertently included. It was evidently missed in the previous screening operation. On October 12, 1999 the small container which held 2- to 3- pounds of sodium metal was shredded, causing the ignition of Tyvek personnel protective clothing in the bottom of the shredder's collection bag. This resulted in an occurrence report to DOE (CH-BH-BNL-BNL-1999-0020).

On the date of this investigation, the report had been submitted by BNL for closure. The report was rejected by the DOE BHG. The DOE Facility Representative cited on the rejections that there was a need to improve the root cause determination. The week prior to the March 2000 fire, the DOE Facility Representative was opening discussions with ERD to close the report.

F. Description of the Incident

When the debris piles were established in 1997, bales of straw were placed around them to control soil erosion. At the end of the debris shredding process, an effort was made to pad the lift liner system. Soil was recommended by the Innovative Technology Report for padding. The debris pile did not have smooth soil. Attempts were made to shred the straw bales (September 13, 1999) but they jammed the shredder. Further shredding of straw was stopped. The intact straw bales were subsequently removed from the debris and stored separately. Pieces of the straw bales that were entrained within the remaining soil and debris were scooped with the soil and following a visual inspection, loaded directly into the lift liners. Lift liner bags DPNR-5S, -6S, -7S for Debris Pile were filled the day of the shredding. DPNR-1D for Debris Pile 2 was filled the following day. Construction logs indicated that is was rainy the two days before the bales were shredded; hence, the bales would have been wet when placed in the lift liners.

The lift liner system for DTS-2 was stacked one layer high, as shown in the previous photograph. A 20 mil polyethylene black cover was placed over the lift liner system to prevent UV light damaging the polyethylene. The covering remained intact until the day of the event.

The 1999–2000 winter weather for Long Island had slightly above-average levels of precipitation. Temperatures ranged between 20°F and 50°F. March 10 was the warmest day of the new year, with record temperatures hitting 65°F.

On Friday, March 10, 2000, a steady wind started to blow to the south at 4 PM. A BNL employee leaving work at 5:30 PM reported smoke coming from the southern part of the site. An investigation by the BNL Fire/Rescue Group did not find a source. There were two large brush fires in the immediate vicinity of BNL. One fire was located to the south in Manorville and one to the north in Ridge. (Several Plant Engineering employees working in the center of the site also reported smelling burning "plastic" the Monday after the fire. Wind direction was to the south and they were up wind - see Attachment E. Some turbulence could have resulted in brief northerly airflow).

On Saturday morning, March 11, 2000 the wind continued to blow to the south. Rain had started to fall the night before. At approximately 8:30 AM, a Radiological Control Technician (RCT) made a routine entry to the Glass/Chemical Holes Project to re-post the radiological signs for the area. Upon approaching the area from the west, he noted a haze over the area drifting south up to the tree line. The RCT stopped when he noticed small flames from the pile. He immediately went to a telephone located at a trailer to the west. The BNL Fire/Rescue Group was summoned at 8:46 AM.

Fire/Rescue responded at the North Entrance of the Glass/Chemical Holes Project and was met by the RCT. Approaching from the west, Fire/Rescue confirmed the appearance of smoke. Determining that the area contained radioactive materials and had potential chemical contamination, the Captain used the Emergency Off-Site pocket pager system to summon assistance. This activates approximately 50 pagers. These alphanumeric pagers notify a crosscut of the BNL emergency response organization. The following is a sample: Analytical Laboratories, DOE, Fire Protection Engineering, Industrial Hygiene, Industrial Safety, Laboratory Emergency Supervisors, Fire/Rescue Officers, Security, and Waste Management. A Base Operational Emergency was declared due to the possible release of radiological and chemical-materials more than 100 feet from the fire area (BNL Emergency Action Level criteria). Security automatically started to notify off-site governmental agencies.

Seven RCT were on-site supporting radiological operations. Three of them carried the emergency pocket pagers and responded immediately upon receiving the page. They responded to the command post. As the scope of the emergency response grew, more RCT responded for assistance. Having more than two RCT on-site after normal hours is infrequent.

Field surveys were started and air-sampling operations implemented. The command post relocated to a sheltered area adjacent to the Employee Picnic area, north of the fire. The emergency response vehicle of the Radiological Assistance Program was brought over to the new command post for radiological support. Responding management personnel opened the Emergency Operations Facility and started management operations from there (crisis management, public information, technical support, monitoring assessment and control).

Polaroid picture made by the initial survey team of the smoking pile of debris. Note, the smoke is low and diffuse. One inch high flames were noted in one or two areas.

In concert with the Emergency Operations Facility Management, a decision was made to send one fire fighter and two RCT into the area to survey the situation.

The survey team approached from the west remained up wind and circled the fire. There was no evidence of radioactive materials leaving the area. Approximately one hour into the event and in concert with the Emergency Operations Facility Management, a decision was made to suppress the fire. No evidence of radioactive materials release was present in any monitoring or survey operation. BNL Fire/Rescue Group entered the area with Radiological Control support. Eight trips were made with BNL's brush truck to extinguish the fire. Each trip delivered 1,000 gallons of water. Personnel and vehicles were surveyed for radiological contamination. No contamination occurred. Consideration was given to breaking up the piles to fully extinguish deeply buried materials (overhaul). Given the possible radiological contamination concerns, over haul was decided against. Return visits by the Fire/Rescue Group to extinguish rekindled fires were anticipated and considered acceptable risk compared to the manual raking of the debris.

Soil and run off samples were taken with continued air monitoring. Post accident sampling was performed. No significant readings above background levels were detected. The scene was secured and a patrol was posted until the investigating team released the area.

The BNL Fire/Rescue Group made three return trips to the same pile to extinguish smoldering debris over the next day. Radiological support was provided.

Debris pile after the fire. This view is looking to the northwest and shows the untouched pile to the south.

BNL's Brush truck spraying water on the fire from the south side of the debris pile. Two covered piles to the south of the main pile remain intact.

IV. Analysis

A. Work Planning, Controls and Feedback

Defining the scope of work

The Characterization Project Work Plan and the Health and Safety Plan were finalized in August 1999. Both plans were reviewed extensively by BNL and DOE personnel. The Characterization Project Work Plan and the Health and Safety Plan identified the broad envelope under which the project was to characterize the debris piles. Both plans are high-level documents and do not contain specific scopes for performing work. As is typical in these types of documents, specific work tasks were not defined for all phases of the project. Definition of work is normally left to job specific task assignments in which job missions are defined, work requirements are established, materials to be used are listed, and adequate safety expectations are expressed. The definition of scope in the job-specific tasks was verbal. The Project's Work Permit section in the Work Planning Section of the work permits referred back to the Safety and Health Plan (i.e., "see safety plan") without citing specific hazards.

There was a one-time training on these documents for all employees. Carry over of the safety issues and precautions from these high-level and technical documents were not evident in the work permits nor in the construction logs. The Project's Work Permit section in the Work Planning Section of the work permits referred back to the Safety and Health Plan (i.e., "see safety plan") without specifically citing hazards, controls, or pertinent procedures.

Identifying and Analyzing the Hazards Associated with the Work

The Characterization Work Plan and the Health and Safety Plan received an extensive review by BNL and DOE personnel. The Characterization Project Work Plan and the Health and Safety Plan identified the broad range of hazards that were expected in the project. Combustible materials were not defined in these plans, nor was a fire identified as a hazard. There was no further revision to the hazards as they translated into the work planning permits. Even after the October 1999 fire in the shredder, the possibility of another fire from the combustible Tyvek PPE or the plastics used at the project was not considered.

After the initial excavation process, the possibility of reactive metals remaining in the waste stream was considered in the fall 1999 shredding operation. The sorting effort on the conveyor belt was thought to have removed almost all of the containers with reactive metal. The shredding efforts were intended to reduce the volume of waste to meet the waste acceptance criteria of the final disposal site's receiving facility. Reportedly, the shredding operations were also intended to reveal any hidden materials. The evaluation of reactive materials becoming exposed during the shredding operations and contacting combustible was internal to the project staff of ERD.

In the original work plan, the container system was described by performance criteria (such as compliance with DOT, 12 months storage). The hazard of using combustible lift liners was not evaluated, nor was that of using combustible padding. The hazard of introducing large pieces of baled straw into the combustible containers was not evaluated.

DOE prepared an extensive report on the soft-sided lift liner system. However, this report did not identify the combustibility of the plastic lift liners as a new hazard in its comparison with metal containers. No information was given in the DOE report on the ease of igniting the lift liner system.

Developing and Implementing Hazard Controls

Once hazards were identified by the project, adequate controls were established to control them as demonstrated by the project's good performance on conventional construction operations.

Working Within the Controls

There is no indication of work being performed outside the established controls whenever hazards were identified and controls established.

Providing Feedback on the Adequacy of Controls, and Continuous Improvement in Defining and Planning Work

BNL has experienced prior instances of spontaneous combustion in organic materials, the most recent being last year. Bales of straw were used for targets at the Brookhaven Employee Recreational Association archery range. During the spring, one bale was found burned to ashes. The fire did not spread past the target stand, and no property damage was incurred. The fire was investigated. The incident did not meet the DOE's Occurrence Report criteria.

Two years ago, another fire occurred involving spontaneous combustion. The Plant Engineering Division at the north part of the site was undertaking a tree-clearing operation. The removed trees were chipped, the chips blended with soil, and screened for composting. One pile of wood chips ignited and smoldered. The fire did not extend past the pile of origin. The fire was investigated by the safety staff. No property was damaged, so a loss report was not generated. A DOE Occurrence Report was not generated, since the event did not meet the criteria.

Over twenty years ago, BNL studied large animals at a dedicated medical facility. Straw was used as bedding in an oxygen enriched environment. The straw started to burn in one of the animal pens, and a worker extinguished it. The safety staff investigated the fire. No property was damaged, so a loss report was not generated. DOE Occurrence Report s did not exist then.

The staff at the Glass Holes Project could have been aware of these experiences if the safety issues of baled straw had been raised.

B. Fire Pre-Planning

Brookhaven National Laboratory Fire/Rescue Group has an emergency response pre-planning system called Response Cards. These cards are a database that is accessible via a web interface. They contain hazard information, controls, and emergency contacts, along with a host of other useful information. Response Cards are accessed via the

Internet. Fire/Rescue accesses the Internet on a laptop computer with a wireless Internet connection. Printed copies are kept by Fire/Rescue in response books, and are typically developed for all buildings and structures. Since this area was outdoors, it did not have an assigned building number. It was not incorporated into the response book system. Release potentials, specific information on pile content and hazards, and emergency contacts able to supply hazard information could have been available at the beginning of the incident. The lack of a release analysis or a release potential would have been raised if a response card had been developed for this hazard material and radiological material processing site.

Based on the October 1999 shredder fire, ERD addressed the need to supplement this emergency response by assigning an Emergency Response pocket pager to the Safety Coordinator. This mechanism failed to provide adequate information at the initial stages of an emergency response.

C. Likely Cause of Ignition

Bales of straw are known from their ability to ignite from heat generated by bacterial action. The presence of organic material, its contamination with bacteria from soil, moisture, heat, and air are required for bacterial activity. The straw is the organic material. Shredding it helped incorporate bacteria into the organic mass. The bales contained moisture from two prior days of rain. Under the correct conditions, the decomposition process raises interior temperatures and the straw will reach ignition temperatures. During the winter preceding the fire, the temperatures were low enough to avoid rapid bacterial growth. March was the beginning of spring. March 10 was the warmest day since September of the previous year. Placing a black tarp on top of the piles dramatically increases the soil pile's temperature. Soil surface temperatures could have exceeded 100°F on the day before the fire.

View of a partially exposed portion of the straw in the debris pile after the fire. This was located in the Northeast section, adjacent to the Personnel Protective Equipment bale.

A less likely source of ignition would have been reactive metals. Sodium, NaK, and lithium are highly reactive when exposed to water. Sodium and lithium combine with water resulting in hydrogen gas, which ignites and burns easily. However, slow exposure of the metals to moisture will result in the formation of an oxide coating on them. The coating must be removed or dissolved for the reactive metals to react with water. During the course of this project, reactive metals flared only when they were disturbed. The soil piles were not disturbed for over four months prior to the March fire. "Breathing in" of moisture from a heating/cooling cycle during the day/night would more likely result in oxide formation rather than a fire. These behaviors were confirmed by discussions with BNL's chemistry staff who routinely deal with sodium.

Smoking materials are prohibited from the radiological areas. There was no indication of smoking materials used in the area and therefore are unlikely sources of ignition.

There was no indication that rodents or other animals had disturbed the debris piles and caused reactive materials to become involved (it is unlikely that reactive materials were present anywhere within the piles).

There is no evidence of vandalism by a disgruntled employee or by local people that would result in fire.

There was no indication of lightning during the rains proceeding the March fire.

D. Environmental Assessments

A. Emergency Phase

During the emergency phase of the fire, on March 11, 2000, Facility Support personnel from the Radiological Control Division (RCD) RCT made direct measurements with survey instruments near the fire at the Chemical Holes. Initial surveys were performed upwind and downwind of the smoke plume for the presence of airborne beta-gamma and alpha radioactivity and for ground deposition. All the survey instrument measurements made on that day for direct radiation showed normal background levels.

There was one anomalous alpha survey instrument reading reported by a DOE-BHG person (a DOE Headquarters employee) who happened to be in the DOE Headquarters Emergency Operation Center (DOE-EOC). The report was characterized by this person as "informal", but was widely distributed within the Emergency Operations Center by DOE Headquarters personnel. The measurement was made by the duty First Responder RCT (FR-RCT) at the initial Command Post, who took the reading alongside a health physicist from RCD. The RCD health physicist discounted the alpha reading as erroneous and requested a second reading with a beta-gamma instrument. The alpha reading was rejected because prior field experience had demonstrated that particulate alpha scintillator-based instrument used could be noisy below 100 dpm. This instrument normally is used with confidence only to assess alpha activity above 100 dpm in routine operations. It also was assumed that a reasonably proportional amount of beta-gamma emitters would have been released concurrently with the alpha component. Consideration was given to the facts that the reading was made well away from the debris pile (over 100 meters) with the wind blowing at approximately a 90° angle from the measurement, and it was taken about one meter above the ground. With these assumptions and the environmental conditions, it was judged that there would have had to be an extremely large inventory of alpha activity in the debris piles to produce such an observation of alpha activity with this instrument. The second instrument (beta) showed background levels for beta-gamma radiation, thus confirming that the alpha reading was not accurate. Neither the Incident Commander nor the health physicist at the Command Post was informed that any data were to be released to the DOE-EOC.

In conjunction with the radiological assessments made during the emergency phase, the plume was assayed for the released hazardous material. At the Command Post, the Project Engineers for the debris site supplied a complete breakdown of the inventory of radiological and hazardous-material in the lift liners. Mercury was one of the constituents.

The presence of an Industrial Hygienist from the Safety and Health Services Division was requested at the Command Post. The debris site Project Engineer informed her that mercury may be present as a constituent in the soil. The Industrial Hygienist provided mercury vapor cartridges to the field team for their respirators and a Jerome Mercury Vapor Monitor XH0505 Model MV2 for assessing the plume. The field team found less than 0.01 mg/m3 in the plume; the ACGIH exposure limit for worker exposure is 0.025 mg/m3. Therefore, this exposure was considered to be the background level for the instrument. When the field team returned, the Industrial Hygienist verified that the monitor was operating properly. A second easy-to-measure indicator of the potential release of hazardous materials from the debris piles would be an unusual pH level in the runoff. The water samples were tested and the pH was found normal.

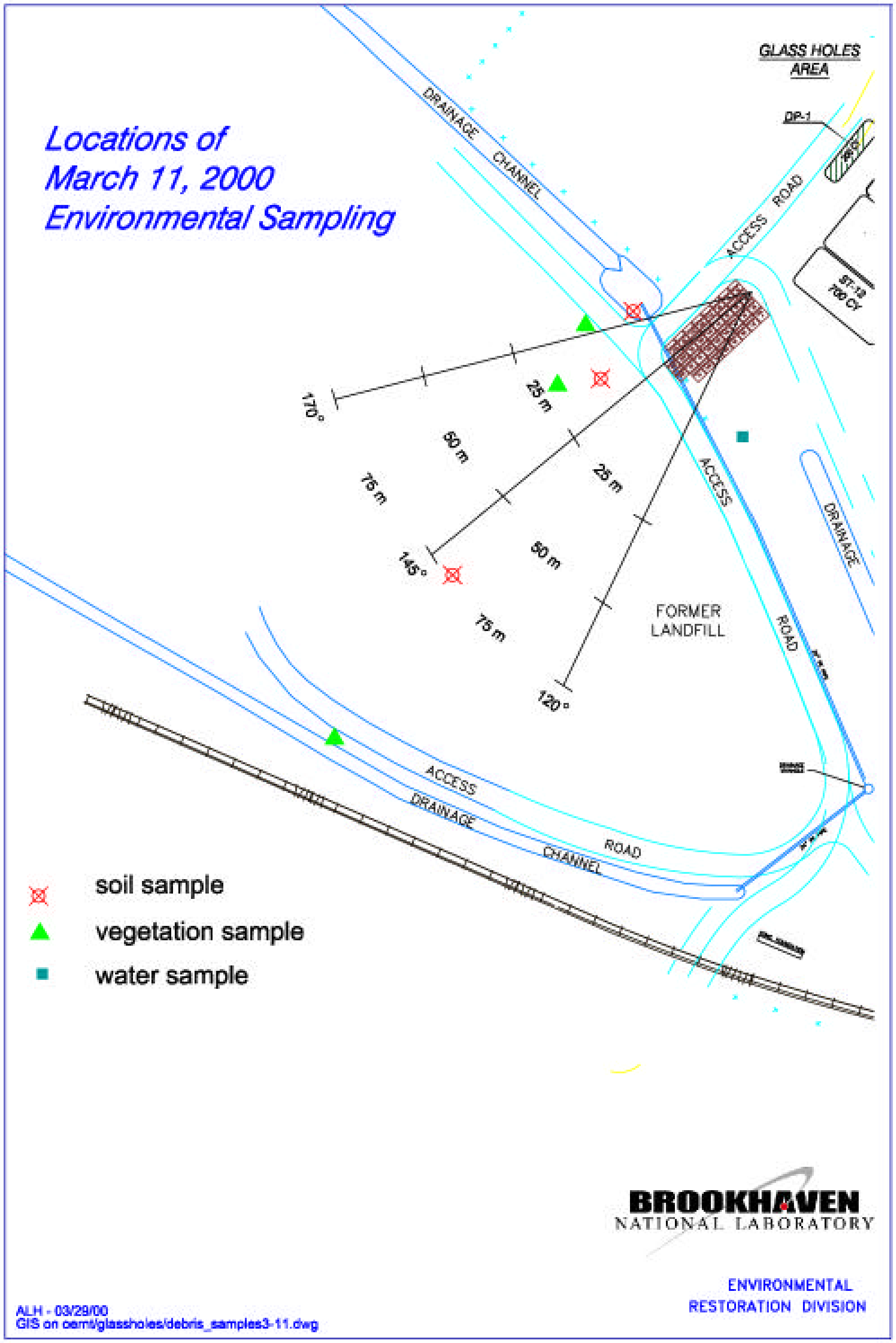
Based on the results of the radiation, pH and mercury surveys, it was concluded that there was no significant release of any material that could impact personnel or the environment. A follow-up assessment was still necessary to ascertain if any lower levels of materials were released.

Following the assessment for direct radiation, the air, surface water, soil and vegetation were sampled. See the figure titled "Locations of March 11, 2000 Environmental Sampling" on next page for sampling locations.

Samples were sent to the RCD Analytical Services Laboratory for radiological analysis. A "quick count" ~15 minutes and follow-up 50 minute counts were performed on air samples. Water, vegetation and soil all received 15 minute counts because the analytical sensitivity was adequate with the 15 minute counting time to judge if an area was contaminated as a result of the fire. Except for one sample of runoff from water from the fire area, all samples were not distinguishable from normal BNL background levels. (COC 20031101, 20031102, 20031103). The one exception (COC 20031104) contained 8.4 pCi/ml, ^{137}Cs.

The following day, March 12, 2000, the fire re-ignited and was again extinguished. The air sample taken then did not indicate a release of airborne radioactivity (COC 20031313).

The analytical sensitivities for water, vegetation and soil were adequate for the team responding to the fire to determine promptly if contamination from the fire had occurred, assure the protection of the personnel and determine if emergency action levels were achieved. A summary of the Minimum Detectable Activities (MDAs) reported for the samples analyzed on March 11, 2000 are shown in Appendix F.

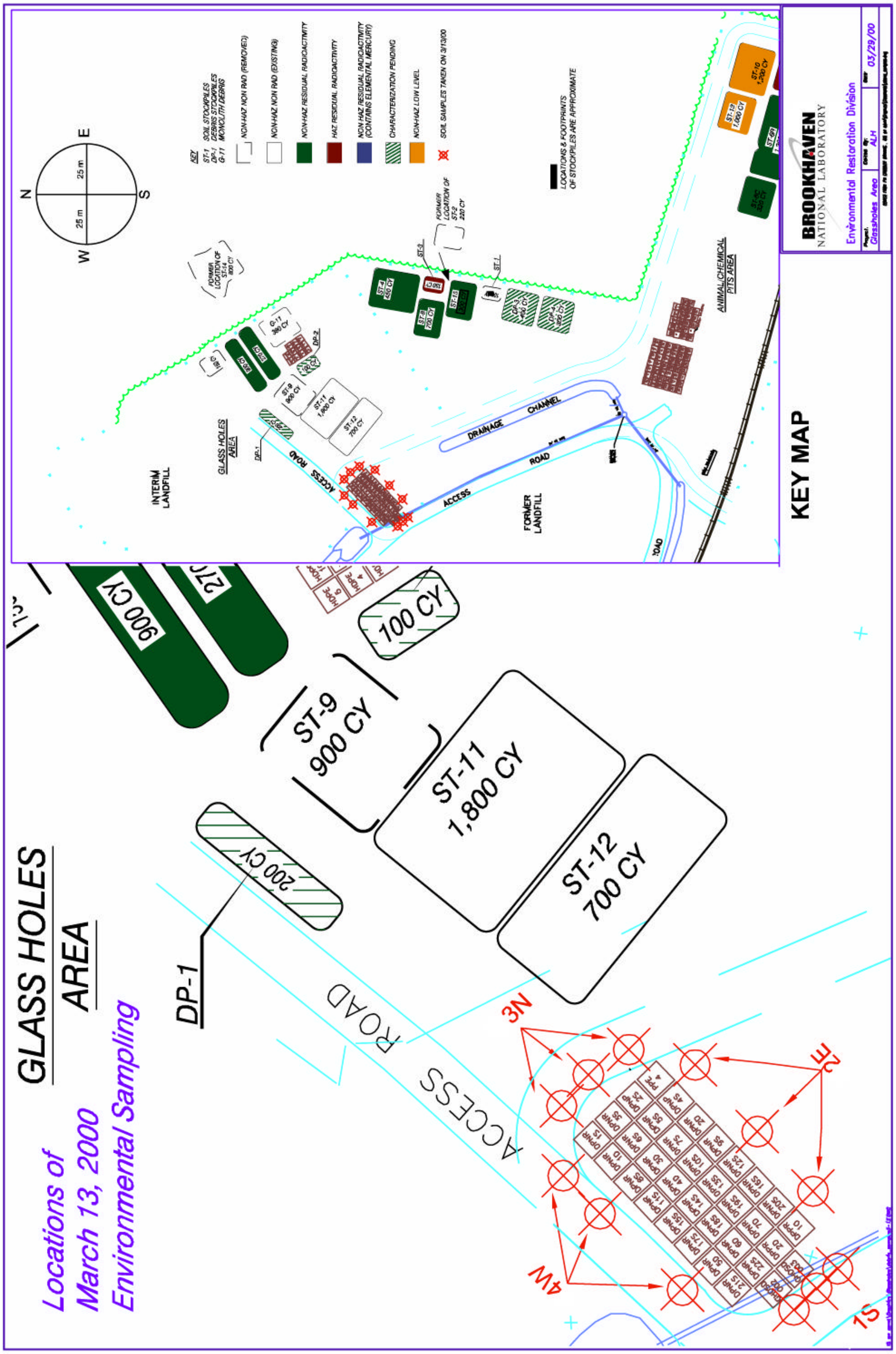

Locations of
March 11, 2000
Environmental Sampling
GLASS HOLES AREA
DP-1
DRAINAGE CHANNEL
ACCESS ROAD
170°
145°
120°
25 m
50 m
75 m
FORMER LANDFILL
ACCESS
ROAD
DRAINAGE
ACCESS
DRAINAGE
CHANNEL
ROAD
soil sample
vegetation sample
water sample
BROOKHAVEN
NATIONAL LABORATORY
ENVIRONMENTAL
RESTORATION DIVISION
ALH - 03/29/00
GIS on oernt/glassholes/debris_samples3-11.dwg

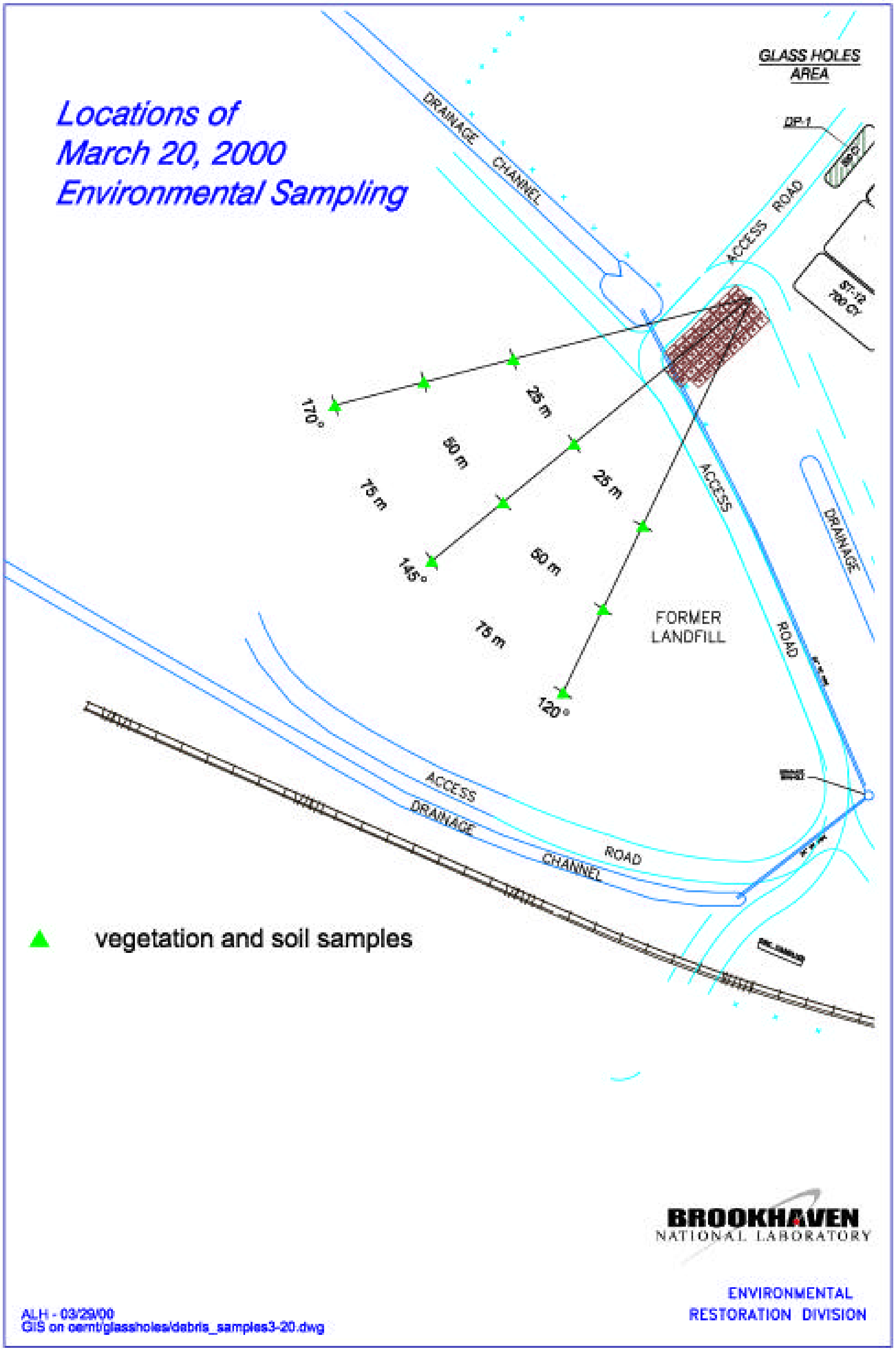
B. Non-emergency Phase

Additional sampling in the area was required to determine if there were any remaining non-emergency levels that could result in environmental impacts from the fire. Therefore, a sampling plan was developed to assess whether any environment impact occurred, and to conduct analysis with lower MDAs for radiological assay. Based on the radiological and hazardous material concentrations in the debris pile, monitoring for radiological constituents, ^{241}Am, ^{60}Co and ^{137}Cs also would identify the need for additional sampling for hazardous materials.

Follow up samples were collected at twelve locations around the perimeter of the debris piles on March 13, 2000 (COC 20031314). The samples were composted into North, South, East and West samples. See the figure titled "Locations of March 13, 2000 Environmental Sampling" on the following page for the locations. The results were non-detect for ^{241}Am and ^{60}Co and normal ambient background ^{137}Cs in all four locations.

Since no detectable levels above background were found in any of the field measurements made during the emergency phase, the follow up plan was based on the meteorology during the previous 24 hours before the fire was extinguished. The wind direction and its variability was very stable from approximate March 10-11; 1600 to 1600 (see Appendix C). Assuming the fire occurred wholly or mostly during that time, a plume centerline of 145° and a width of ± 25° was used as the basis for sampling. This aperture was superimposed on a map of the area and sampling locations were located in 25-meter increments. See the figure titled "Locations of March 20, 2000 Environmental Sampling" on the following page. A surveyor sited the locations. The sampling plan is shown on the following page. The results for all twenty samples (soil and vegetation) were non-detect for ^{241}Am and ^{60}Co and at normal ambient background ^{137}Cs at all four locations (COC 20032009). The lack of radiological contamination is a valid surrogate to conclude that no follow up sampling is necessary to further assess deposition of hazardous materials.


GLASS HOLES AREA
Locations of March 13, 2000 Environmental Sampling
DP-1
200 CY
ST-9 900 CY
ST-11 1,800 CY
ST-12 700 CY
100 CY
900 CY
ACCESS ROAD
3N
3E
4W
1S
KEY MAP
INTERIM LANDFILL
FORMER LANDFILL
DRAINAGE CHANNEL
ANIMAL/CHEMICAL PITS AREA
LOCATIONS & FOOTPRINTS OF STOCKPILES ARE APPROXIMATE
BROOKHAVEN NATIONAL LABORATORY
Environmental Restoration Division
03/29/00


Locations of
March 20, 2000
Environmental Sampling
GLASS HOLES
AREA
DP-1
DRAINAGE CHANNEL
ACCESS ROAD
170°
145°
120°
25 m
50 m
75 m
25 m
50 m
75 m
ACCESS
DRAINAGE
FORMER
LANDFILL
ROAD
ACCESS
DRAINAGE
CHANNEL
ROAD
vegetation and soil samples
BROOKHAVEN
NATIONAL LABORATORY
ENVIRONMENTAL
RESTORATION DIVISION
ALH - 03/29/00
GIS on cemt/glassholes/debris_samples3-20.dwg

Fire Tests of Materials

A small-scale test was conducted on the lift liner material and the polyethylene cover. Small-scale testing does not fully represent how a material will behave in a fire, but is typically used to screen out extremely combustible materials. Borderline hazards and low hazard plastics normally pass these small-scale tests.

Two 4" wide by 12" long layers of 20 mil woven lift liner fabric were suspended vertically from a bench vice. Together with a 20-mil polyethylene sheet, the fabrics were allowed to hang, with air spaces between layers. A butane cigarette lighter (on low flame) was used to ignite the finished bottom edges of the samples. The edges of the samples melted quickly. Once melted, an orange and blue flame appeared close to the surface of the plastic. The flame's front proceeded up the fabric and progressed two inches in 15 seconds. The flames then were extinguished by the test crew. "Ease of ignition" also was tested on the frayed edges of the woven fabric and was found to be just as ignitable. The woven fabric burned as most plastics burn, by melting and burning as a liquid. Dripping from the woven plastic was readily evident. The polyethylene did not drip in the test since it was not allowed to burn long enough. It did exhibit melting features that would have allowed it to burn in a liquid state.

This manner of burning indicates that the woven plastic alone could sustain burning. Most likely, the polyethylene cover probably burned across the top of the soil piles. As materials dripped from the burning polyethylene, the woven materials ignited. The burning across the top of the piles could have taken a long time given the closely spaced crevasses between the Super Sacks. Plastics do not absorb water. Therefore, the light rain did not affect the burning of the polyethylene or the woven fabric. This is a typical characteristic of plastic and it is one that makes plastic a significant fire challenge.

It should be noted that the lift liner manufacturer's data on flammability is based on an ASTM E-84 Tunnel fire test. This test is not recognized as being a valid tool to evaluate flammability of plastics. The E-84 Tunnel is 24 foot long, has a sample attached to the ceiling, air is blown down the tunnel, and a burner is at one end. After ignition of the burner the flame travel is measured over time to determine how fast a material spreads flame. Since plastics melt and drip as they burn, the placement of the sample at the ceiling keeps flame spread down. Since plastics burn in the gas phase, the induced draft further reduces the test's ability to measure how fast a plastic will burn in real life. The Class A rating received by the lift liner system (the best rating achievable and equal to cement board for flame spread) is considered invalid by fire professionals.

F. Physical Observations

The fire area was evaluated in detail shortly after the fire. It was noted that almost the entire exposed sections of the lift liner system and the black polyethylene UV cover were consumed. Only at two locations did the polyethylene UV cover remain intact on the top of piles. The majority of lift liner materials were burned down below the visible soil line The forceful water streams from the fire hoses during extinguishing may have exposed these areas of the lift liners.

Remaining portion of lift liner left below the soil line after the fire.

One section of the polyethylene cover had broken free of the pile and traveled west of the pile by approximately 5 feet (see the following picture). Sandbags holding down the 20-mil polyethylene cover were scorched only on the west side, indicating the area was not burned from the main pile. This damage may have been due to a forceful updraft from a hot burning spot in the pile. This region corresponds to an area where the Fire/Rescue Group reported difficulty in extinguishing the fire and experienced the rekindling of the flames.

Area to west of main pile indicating portion of the PVC cover blew off and burned.

Pieces of wood were scattered in the debris piles. The surfaces of the wood were lightly charred, but there was almost no "checkering" on the surface of the charred wood. The char was only surface deep. This finding indicates a fire of a short duration and low heat energy passed by the pieces of wood.

The post-fire investigation showed that there were unburned plastics and other combustibles at the surfaces of the piles. The force of the Fire/Rescue hose streams during suppression probably exposed these materials.

During the initial fire suppression, fire fighters reported hearing "popping" sounds above the noise from the diesel fire engine and radio communications. Small fountains of "blue-green" and "turquoise" flames were reported while water was sprayed in the Northwest pile corner. The cause of this is unclear. It may have been due to molten burning plastics in the crevasses between the soil piles, which may have splattered as water was applied. Another explanation maybe that residual chemicals were in the soils and so colored the flames.

The way that the lift liners were stacked left spaces of two to three inches between containers. With two adjacent Super Sacks, approximately 130 mils of woven fabric would fill these spaces. The soil behind the woven fabric would reflect heat to perpetuate burning. Polypropylene is not expected to burn rapidly. Given its thickness, and the high surface-to-air ratio of woven materials, the fabric would burn slowly for hours. The crevasses between the soil pile entrained air into the woven material as it burned. As the lift liners became structurally weak, the soil probably spilled from the container creating voids, allowing the subsurface material to burn.

G. Ignition Time of the Fire and Initial Location of Fire

The fire most likely started late in the afternoon of March 10, and continued to burn through the night. March 10 was the warmest day of the year. Personnel spotted a smoke column coming from the direction of the Glass Holes Project the evening of March 10. To develop such a high smoke column, the fire had to be initially intense. The lift liner system and the polyethylene cover would be a reasonable source to produce the continued burning. The piece of black polyethylene that flew off the top of the piles and burned 5 ft. west of the pile had to originate from the more intense burning spot on the debris piles, by the south portion of the piles. This coincides with the “hot spot’ location where Fire/Rescue had difficulty extinguishing the fire. Based on the burning characteristics of the plastic (see Fire Test of Materials discussion), the fire could have burned slowly the rest of the night, until the morning of March 11 when it was discovered.

H. Infrared Scans of Piles

Following the fire, an infrared camera was used to examine the debris remaining from the piles. While the exterior temperatures were in the 40°F range, there were no indications of "hotspots.' Three other storage areas existed. Some of the lift liner system containers from DTS-3 were hoisted and examined by the infrared camera. No hot spots were detected. Attempts to scan the remaining storage areas through the black polyethylene covering gave little information because the black covering masked any temperature differential.

Infrared camera being used from a manlift to scan the debris piles.

V. Conclusions and Judgement of Needs

Conclusions	Judgement of Needs
The emergency response to the incident was effective. Additional pre-fire information on hazards information would have assisted the first responders with evaluation. Lessons-learned from the October 1999 fire could have provided guidance on improving pre-fire planning. Radiological and hazardous materials were not released from the fire. The fire burned the majority of the combustibles on the surface of the pile; this outcome represents a worst-case fire and a worst-case release scenario. A pre-fire evaluation might have determined this maximum release scenario and avoided having to declare a Base Operational Emergency.	There is a need to have pre-fire plan information for operations that are not associated with a building.
Straw within the debris piles was ignited by spontaneous combustion. The rains before the shredding of the bales, the high spring temperatures, and “solar heating” of the black HPDE covering provided the correct conditions for increasing bacterial action. The fire hazard from the plastic lift liner was not considered in the DOE evaluation of the lift liner system. Therefore, the Project’s internal decisions did not identify this as an issue. Consequently, there were no controls to address combustible materials. The Project did not have an adequate feedback process to incorporate lessons-learned from other fires elsewhere at BNL. Lessons learned from earlier fires involving bales of straw could have flagged the hazards. The lessons-learned from the Project’s October fire could have provided controls to manage the fire risks of combustible materials. Soils were recommended for padding the lift liner system. Internal reviews that evaluated alternative padding methods to avoid punctures of the lift liners did not identify the risks of shredded combustible materials or bales of straw.	There is a need to review management controls and systems for assessing and controlling the hazards of the facility operations. There is a need to improve the level of review so important activities and equipment can be defined, and controls developed and implemented. DOE should be notified of the issues on the combustibility of the lift liner system.
It could not be determined if there were other bales of straw in the three remaining piles of debris. The fire began many hours before its discovery.	There is a need to develop a plan to deal with the hazards associated with the remaining piles of debris potentially containing bales of straw.

VI. Signatures

The investigation was conducted and the report prepared by

William E. Gunther, P.E.
Senior Environmental Advisor
Environmental Management Directorate
Member

Joseph W. Levesque, Fire Protection Engineer, M.S., A.S.P
Deputy Division Manager of Emergency Services
Brookhaven National Laboratory
Chairman

Stephen V. Musolino, Ph.D., C.H.P
Radiological Control Division
Brookhaven National Laboratory
Member

VII. Appendices

Appendix A – Appointing Letter

Appendix B – List of Interviewees

Appendix C - List of Documents Reviewed

Appendix D – Sample Container Inventory Sheet

Appendix E – Meteorological Information on Wind Direction

Appendix F – Table of Data Collected and Minimum Detectable Levels

Appendix A

March 13, 2000 memo from M. Schlender to J. Levesque, S. Musolino, and W. Gunther,

"Committee to Investigate the Fire at the Glass Holes Area,"

Appendix B

List of Interviewees

Barone, Roy	Emergency Services Division
Brower, James	Environmental Restoration Division
Centore, Stephen	Department of Energy
Dikeakos, Maria	Department of Energy
Eberle, Michael	Dames & Moore (by written statement)
Epple Andrea	Radiological Control Division
Galitelli, Joseph	Emergency Services Division
Larsen, Paul	Emergency Services Division
Layendecker, Stephen	Radiological Controls Division
Leigh-Manuell, William	Emergency Services Division
Litzke, Robert	Environmental Restoration Division
Lockwood, Andrew	Environmental Restoration Division
Marotta, Frank	Emergency Services Division
Mergan, Dorian	Radiological Control Division
Newson, Clyde	Environmental Restoration Division
Olsen, Donald	Radiological Controls Division
Pemberton, William	Radiological Control Division
White, Otto	Safety & Health Services Division
Yerry, James	Emergency Services Division
Yezek, Charles	Plant Engineering

Consulted for technical issues:

Bullock, Morris	Chemist, Brookhaven National Laboratory
Nelson, Rod	D&D Project Manager, Idaho Engineering & Environmental Laboratory

Appendix C

List of Documents Reviewed

April 10, 1999 memo J. Eckroth to A. Lockwood, S&H Services Division Review – Health and Safety Plan for the Debris Processing and Characterization Effort at the Chemical Holes Project

April 9, 1999 memo N. Berholc to J. Eckroth, Chemical Holes Project review.

August 16, 1999 memo from J. Eckroth to A. Lockwood, S&H Services Division Review – Health and Safety Plan for the Debris Processing and Characterization Effort at the Chemical Holes Project.

DRAFT March 1999 Innovative Technology Summary Report, The Soft-Sided Waste Container System, prepared for the U.S. Department of Energy, Office of Environmental Management, Office of Science and Technology, Deactivation and Decommissioning Focus Area.

Material Safety Data Sheet, Polypropylene Fabrics, Transport Plastics, Inc, 190 Transport Drive, P.O. Box 12, Sweetwater, TN 37872, no date

Re-evaluation of Soft-sided Packing to DOT Radioactive Material Packaging Requirements, Transport Plastics, Inc, 190 Transport Drive, P.O. Box 12, Sweetwater, TN 37872, P&T-EDF-036, no date.

“Health and Safety Plan for the Debris Processing and Characterization Effort at the Chemical Holes Project,” prepared for Brookhaven National Laboratory, Upton, New York, BNL Contract No. 7994004-Task Order No. 19, August 1999, Prepared by Environmental Resources Management, 175 Froleich Farm Blvd., Woodbury. New York 11797.

“Debris Characterization Work Plan for the Animal/Chemical Pits and Glass Holes,” prepared for Brookhaven National Laboratory, Environmental Restoration Division, Upton, New York 11973, August 1999, Prepared by P.W. Grosser Consulting.

“Brookhaven National Laboratory Environmental Restoration Division Critique Report, Operable Unit I Waste Characterization/Sorting/Shredding/packaging Pyrophoric material Incident”, undated critique report of the October 12, 1999

Brookhaven National Laboratory Meteorological Records from Bldg. 51’s Tower, March 10 through March 11, 2000

Brookhaven National Laboratory Fire/Rescue Group Basic Incident Reports number 00-058 (3-11-00 fire), 00-059 (3-12-00 rekindle), 00-060 (3-12-00 rekindle).

Brookhaven National Laboratory Occurrence CH-BH-BNL-BNL-1999-0020, regarding the shredder bag fire at the Chemical/Glass Holes Project.

Various Radiological Survey Records and Industrial Hygiene Survey Records pertaining to the Fire Incident of March 11, 2000.

Environmental Restoration Division Work Permit for the Characterization of the Debris Piles from the Glass Holes Project.

BNL Chemical Holes Project, Debris Processing and Characterization Health and Safety Log, 8-25-99 to 11-2-99, John C. Sheena

BNL ERD Chemical Holes Debris Processing Daily Summary Sheets, 8-16-99 to 11-10-99

Dames and Moore Construction Log Book “Debris-Processing, Chemical Holes, 8-18-99 to 10-27-99”

Appendix D

April 3, 2000 memo from A. Lockwood to J. Brower,

"Summary of Work Plan and Heath and Safety Plan reviews – Debris Characterization Project"

Appendix E

Meteorological Information on Wind Direction

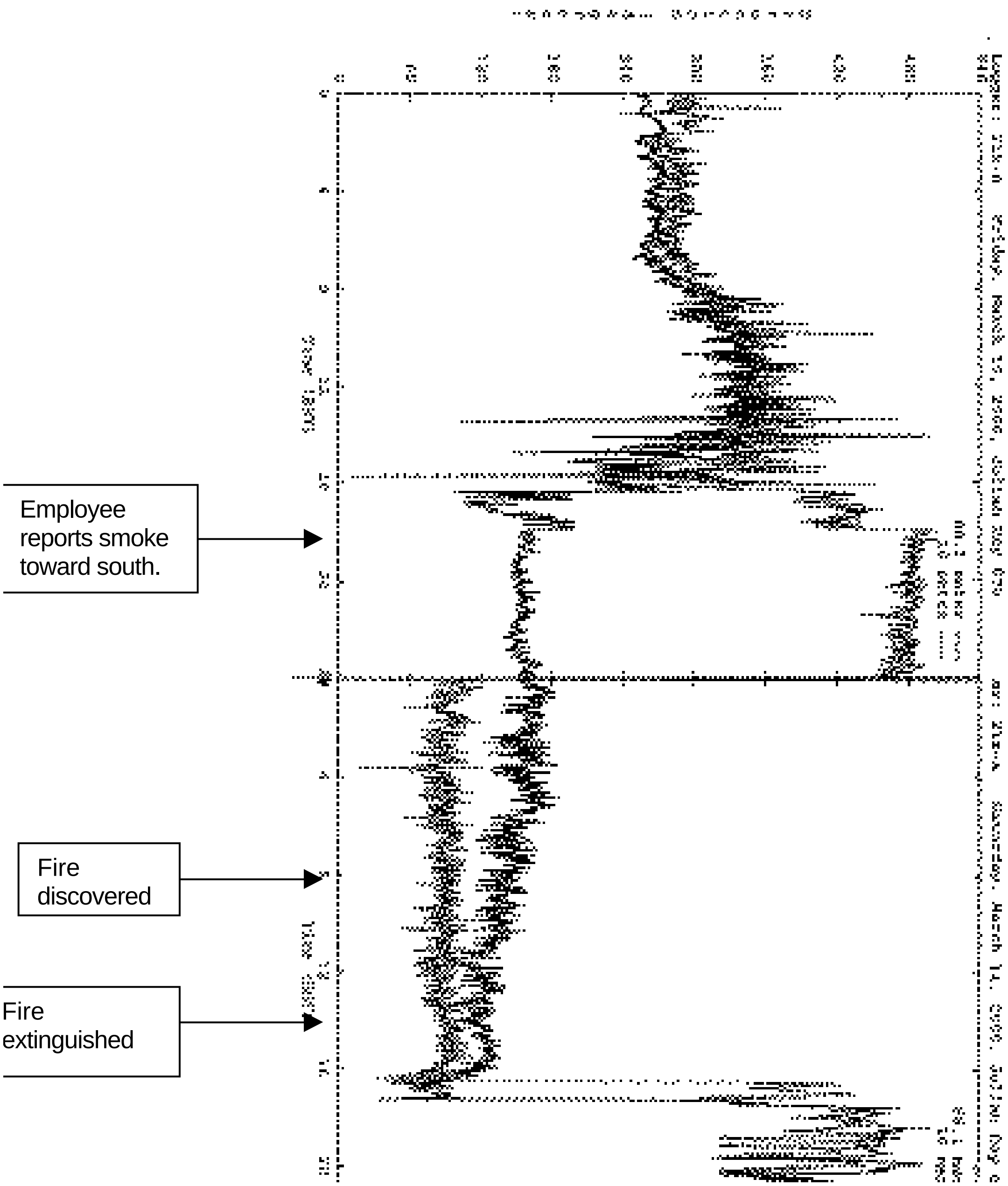


Chart shows wind direction from the Meteorological tower located by Bldg. 51 for March 10th to March 11th.

Note:
To avoid confusion when swinging wind directions are displayed, numbers above 360 are allowed. Subtract 360 from those higher numbers to get the standard 0 to 360 degree wind direction readings.

Appendix F

Minimum Detectable Activities (MDA)

C.O.C. Number		
20031101		
MDA		
Am-241	**Cs-137**	
4.21E-10	7.89E-11	✪Ci/cc
1.94E-11	3.94E-12	
3.03E-10	7.75E-11	

C.O.C. Number		
20031102		
MDA		
Am-241	**Cs-137**	
9.70E-11	1.49E-11	✪Ci/cc
5.20E-11	8.70E-12	

C.O.C. Number		
20031103		
MDA		
Am-241	**Cs-137**	
2.30E-11	3.50E-12	✪Ci/cc
1.50E-06	5.00E-07	✪Ci/g
1.50E-06	1.40E-07	
1.00E-06	8.60E-08	
5.40E-06	1.00E-07	
2.20E-06	1.30E-07	
1.70E-06	1.50E-07	
3.80E-07	1.60E-07	✪Ci/cc
3.00E-07	1.10E-07	✪Ci/cc

C.O.C. Number		
20031104		
MDA		
Am-241	**Cs-137**	
2.41E-07	4.42E-08	✪Ci/cc