APPENDIX E

RECOVERY PLAN

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DRAFT LAUNCH VEHICLE AND PAYLOAD RECOVERY PLAN

NASA SOUNDING ROCKETS PROGRAM AT
POKER FLAT RESEARCH RANGE

National Aeronautics and Space Administration

Goddard Space Flight Center

Wallops Flight Facility

Wallops Island, VA 23337

September 2012

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CHANGE RECORD SHEET

ISSUE	DATE OF RELEASE	REASONS FOR REVISION	APPROVAL
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1.0 INTRODUCTION

1.1 BACKGROUND

The NASA Sounding Rockets Program (SRP) has launched suborbital sounding rockets from the University of Alaska Fairbanks (UAF) managed Poker Flat Research Range (PFRR) since the late 1960s in support of basic space and atmospheric science research. Until now, there has been no formal plan or policy specifically addressing recovery of flight hardware from downrange lands. Historically, recovery of payload and vehicle components has been performed on an as-needed basis with the requirement to do so dictated primarily by the respective mission's scientific investigator.

1.2 POLICY

It is now NASA's policy to provide for a "clean range" at PFRR whereby all launch related hardware that can be effectively located and identified on downrange lands will be removed when deemed practicable by the landowner, UAF, and NASA. This policy applies to future launches as well as hardware remaining in downrange lands from past sounding rocket flights, including those sponsored by non-NASA entities. It is recognized that locating all of the small objects over such a vast area presents a number of technical challenges that cannot be addressed by current technology. However, NASA is committed to implementing a multi-tiered approach that addresses both past and future launches in order to continue operations at PFRR within a sensitive environmental context.

1.3 PURPOSE OF THIS DOCUMENT

The purpose of this document is to outline the general practices that NASA and UAF will employ to locate and remove flight hardware from within PFRR's downrange lands (see **Figure 1**). It is not intended to provide details of specific recovery operations, as these will be situation specific and dependent on multiple factors including weather, location of the hardware, etc. Additionally, this document does not provide a comprehensive discussion of PFRR operations or an assessment of potential environmental effects. For this information, the reader is directed to the 2000 *Final Supplemental Environmental Impact Statement for the NASA Sounding Rockets Program* and the 2012 *Draft Environmental Impact Statement for the NASA Sounding Rockets Program at Poker Flat Research Range*.

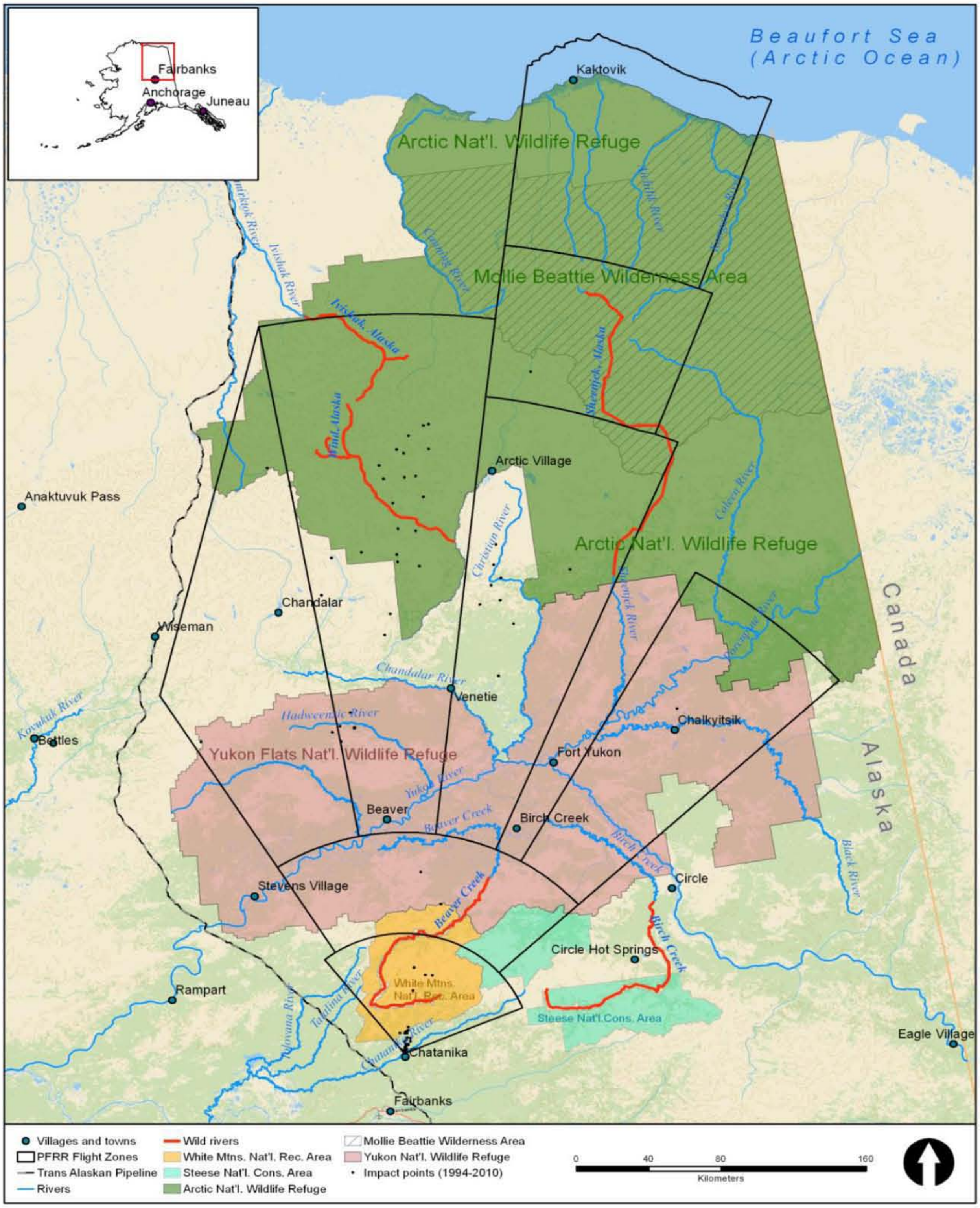


Figure 1. Poker Flat Research Range Launch Corridor and Downrange Lands

2.0 PROGRAMMATIC COMMITMENTS

2.1 CONTINUAL IMPROVEMENT OF LOCATION AIDES

Accurately locating flight hardware in downrange lands is very difficult given the vast area encompassed within the range boundaries (approximately 114,000 square kilometers) and the relatively small size of the targeted items. Given this challenge, NASA will continue to research and evaluate technologies and methods that could improve its ability to locate all major sections of flight hardware, including each rocket motor and the main payload assembly. Listed below are methods/practices currently being tested and/or flown that have shown the most promise:

Radar/Global Positioning Systems **–** GPS systems that do not require a line-of-sight telemetry link to the launch site have been successfully tested on several recent sounding rocket flights. One system, which relies on the Iridium constellation of earth-orbiting satellites, survived flight and provided reliable coordinates for the location two parachuted payloads in the 2011 launch season. It should be noted that this system had been flown several times before with no success; however the continual testing uncovered a technical detail that once resolved has provided very promising results.

Implementation of a system to provide location data for rocket motors; however, has proven to be more challenging due to the harsher flight environment. A system that relies on a commercially available GPS was flown on an April 2011 mission; however it did not survive flight. Given this challenge, NASA is currently working with providers of location devices designed specifically for high-impact environments to determine if such a system may be technically feasible for sounding rockets.

Analytical Predictions – The NASA Safety Office has recently developed enhanced techniques for determining the impact location of rocket motor stages and payload components. Once the vehicle is no longer thrusting (all its fuel has been consumed), the objects follow a simple ballistic trajectory. To enhance the probability of locating these objects, flight safety analysts have more effectively combined datasets provided from payload telemetry systems (known as the “state vector” which encompasses position, velocity, direction, and momentum) with atmospheric wind measurements taken during the launch process. This provides the most accurate prediction of the impact site, as it is based on the actual flight path of the rocket, and it can be performed for all objects released as part of the experiment (nose cone, sub-payloads, main payload, etc.). Using current computer-aided analytical tools, it can be accomplished within several hours of the actual launch, thus expediting the search phase of the recovery operations. The methodology has been employed on recent PFRR-launched missions and has proven helpful in refining location estimates for items that are not tracked by radar nor have onboard telemetry equipment (e.g., rocket motors). NASA will continue to refine this process that has become a standard post-launch procedure for PFRR launches.

Non-Traditional Location Aides – In addition to electronic devices, NASA has recently employed visual aides to assist in the location of rocket motors. For example, on an April 2011 mission, both ejectable strobe lights and search and recovery streamers were added to the head cap of the second stage motor, however neither proved to be successful as the motor was not located. The application of fluorescent colored markings on the rocket motors has recently been employed at PFRR. Although this technique would only prove effective if the motor landed on its side (and was not covered by snow), it is possible that these markings could assist in the location of stages during the non-winter months when snow would be absent. NASA and UAF will continue to evaluate the use of non-traditional location aides deemed technically feasible.

2.2 RECOVERY BUDGET

Each Fiscal Year, NASA will allocate a minimum of $250,000 of the PFRR annual budget for recovery activities. Actual expenditures are expected to vary from year to year, and would be dictated primarily by launch activity, the amount of hardware reported by agencies and members of the public (discussed in more detail below), the limited time available to recover hardware dictated by weather, and the limited seasonal availability of recovery assets (primarily rotary wing aircraft). If needed, available recovery funding from one previous Fiscal Year could be utilized to augment the $250,000 recovery budget if circumstances warranted, such as if members of the public report a much larger amount of hardware.

Prioritization of Recovery Funds – As the PFRR annual recovery budget would be essentially fixed from year to year, and to maximize available funds, NASA would have to assign priority to recovery from downrange lands. Highest priority would be given to Wilderness areas followed by Wild and Scenic River Corridors. After these areas are addressed, priority would be dictated by which identified recovery would remove the most flight hardware in the least amount of time for the least cost. In performing recovery, it would be NASA's intent to maximize economies of scale or "out of the box" recovery opportunities, such as the employment of government firefighting or natural resources related personnel who may already be present in the vicinity of an identified flight hardware item. Accordingly, these opportunities would be given elevated priority once recovery of items within the most sensitive lands was satisfied.

2.3 SEARCH FOR ALL NEWLY LAUNCHED STAGES AND PAYLOADS; RECOVER IF PRACTICABLE

NASA and UAF will conduct post-launch searches for the on-land flight hardware components (i.e., rocket stages and main payload) for all future missions. This has been implemented for 2011 and 2012 launch seasons with varying degrees of success. Missions are planned such that a fixed wing search of the predicted impact areas are conducted as soon as practical after launch; generally the next day at first light. The concept is to look for freshly disturbed areas of snow before the objects are covered with windblown snow or additional precipitation. If flight hardware is successfully located within downrange lands, a decision-making process (involving the respective landowner) then follows to determine the necessity and practicality of performing a recovery operation as outlined below.

It is important to note that the focus of the recovery efforts is the downrange lands located north of the State of Alaska special use property just across the Steese Highway from the PFRR launch site. Given the land use within the special use property; there is heightened sensitivity to land-disturbing activities, particularly those associated with a recovery operation. Therefore, regular (i.e., annual) recovery activities would likely not take place within this property. NASA and UAF intend to remove easily accessible spent rocket motors on an occasional basis in coordination with the property's managing organization, however it is expected that these efforts would less frequent (e.g., every several years) and would likely result in a greater proportion of those left in place (as compared to other properties within the flight corridor) if is determined that a measurable amount of land disturbance would be required.

2.4 LEVERAGE AVAILABLE OUTSIDE RESOURCES

NASA is aware of the numerous commercial and private aircraft that overfly the downrange lands, particularly during the non-winter months. Also, the large amount of downrange land that is either hunted or fished on a regular basis, particularly by hundreds of subsistence users, lends itself to a partnership opportunity for locating flight hardware. UAF will employ Alaska Native Village residents in search efforts to the extent practicable. For certain missions that have expected hardware landing locations within either Tribal lands or within areas historically used by a particular Village regardless of land ownership, PFRR will consult with the respective Village Council.

Rewards Program – NASA and PFRR will institute a formal rewards program to assist in locating and recovering rocket and payload hardware. A public awareness campaign (discussed below under ***Outreach***) will be mounted to inform villages, hunters, resource agency personnel, and others, as appropriate, of the rewards program. The public will be instructed to contact PFRR and provide GPS coordinates and a photograph (or verbal description) of the suspected item. Assuming that the report appears credible, PFRR would then commission a flight to confirm the item's location and its disposition. If the item were confirmed to be a component of a sounding rocket flight, UAF would then pay the reward to the person who originally reported the item. The reward will vary depending on what the item is; the highest reward would be paid for spent rocket motors, and all other flight hardware (e.g., payload, nosecone, doors, etc.) would have the same lesser reward value. To avoid the potential for paying multiple rewards for the same object before its ultimate recovery, the reported item's location will be recorded in the UAF-managed database for future reference. Funding for rewards will be taken from the ***Recovery Budget*** discussed above. In the 2011 and 2012 launch seasons this concept has been tested, and has proven to be one of the most successful means of locating expended flight hardware.

When possible, each major component on future missions, including each vehicle stage and main payload, will have contact information affixed to it for positive identification. Depending on mission requirements, this could be a plate attached with words inscribed, stamped, or stenciled in paint.

***Rewards Eligibility* –** Consistent with the goal of focusing recovery efforts on lands north of the special use areas immediately across the Steese Highway from the PFRR (Alaska Department of Natural Resources Poker Flat North and South Special Use Areas), the Rewards Program will not apply to these lands. Additionally, resource agency personnel who locate items when performing their official duties as public employees will not be eligible for payment.

2.5 EVALUATE REPORTS OF ITEMS FROM PAST FLIGHTS; RECOVER IF PRACTICABLE

Consistent with the process outlined above under ***Rewards Program***, when agency personnel or members of the public report items, UAF will evaluate the report, perform a reconnaissance flight if necessary, and then recover the items as described below.

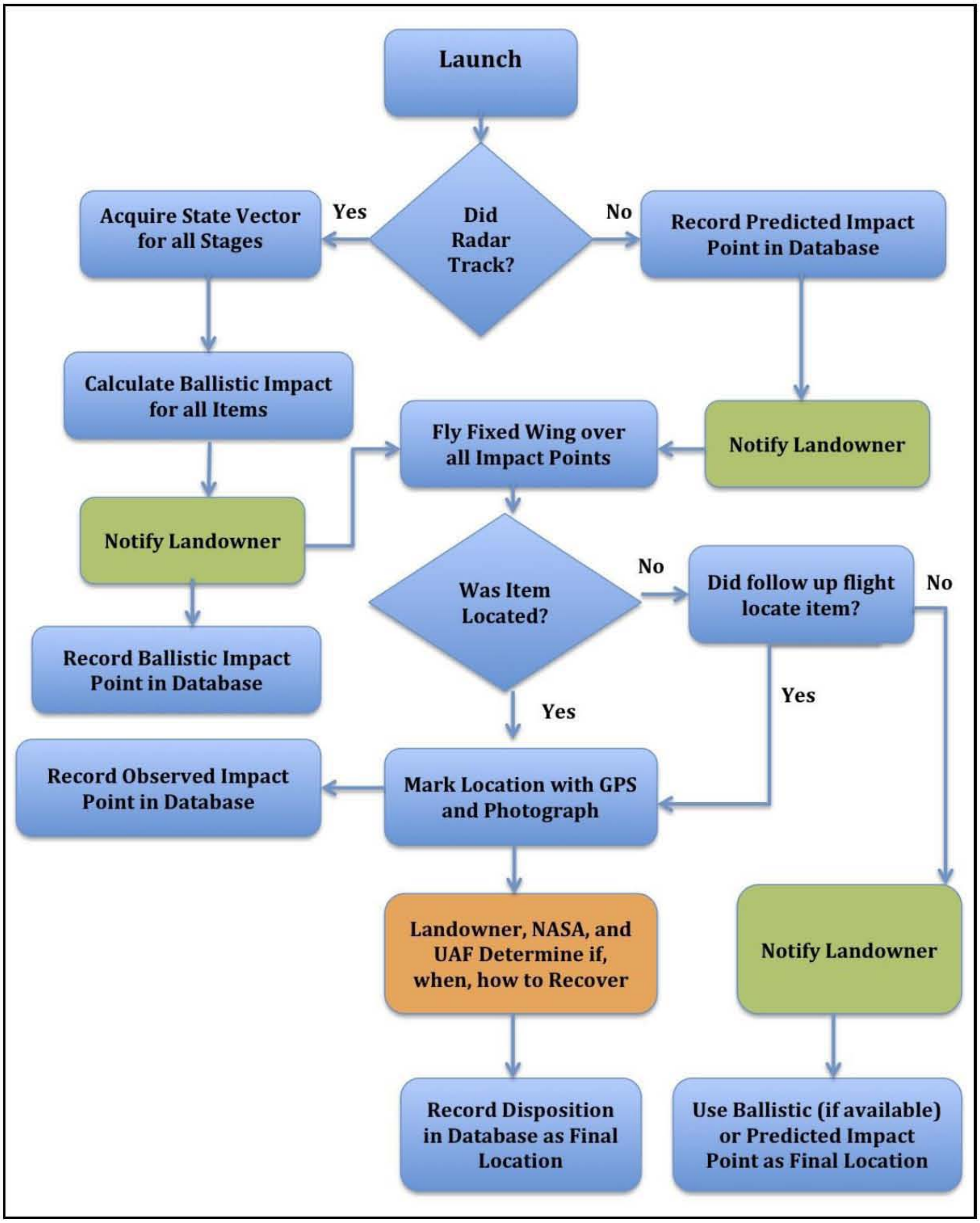
3.0 LOCATION AND RECOVERY PROCEDURES

3.1 LOCATION

Figure 2 outlines the process by which post-launch search operations would be executed. The most effective way to predict the location of the major launch-related items is to use the actual burnout conditions (state vector) and calculate a ballistic impact using state-of-the-art trajectory programs.

This process would involve immediate collection of the last available position data (either GPS or radar) and use of these data in trajectory simulation programs to calculate impact points for all stages and major payload pieces (as described above under ***Analytical Predictions***).

Once NASA's flight analyst has provided these points, they will be entered into the PFRR recovery database (discussed below under ***Recordkeeping***), and arrangements would then be made to fly an aircraft over the points. The goal would be to do this as soon as possible after launch (within 24 hours if practicable), such that snow would not cover the items prior to the search. Due to launch times driven by scientific conditions, coordination with aircraft providers, limited daylight or weather constraints in winter months, and the impact range of some objects, it may not always be practical to meet the 24-hour goal. In these instances, it may be elected to wait until the snow has melted to begin the search. Regardless, coordination with the landowner will be part of the decision process. In all cases, the landowner (e.g., Yukon Flats NWR, Arctic NWR, and/or BLM) will be offered a seat on the recovery aircraft to assist in spotting any objects. Given the potential for either short-notice or early morning search flight, or both, the landowner will be asked to provide a phone number and point of contact each launch season. The designated point of contact will be notified of pending search operations as soon as practicable, however if no response is obtained, the search flight will be initiated in an effort to maximize the potential for locating an object prior to new snowfall. If the objects are not located immediately after launch, at least one additional flight will be conducted as soon as practical after snowmelt to see if the object can be located.



*****Green** shapes indicate landowner **consultation** required; **orange** indicates landowner **approval** required before proceeding*

Figure 2. Post Launch Search Process Flow Chart

3.2 RECOVERY

Once an object has been located, pertinent information needs to be collected about the impact site such that an objective decision can be made whether to attempt a recovery. During the decision making process, the recovery team will consult local landowners to seek their input as recovering pieces of hardware in remote lowlands or mountainous terrain presents a number of technical and logistical challenges. Proximity to roads or landing sites, the type of terrain, type of vegetation, safety of personnel, the size of the object, season, and sensitivity of the impact site are all factors that must be considered when planning a recovery operation. If recovery is to be attempted, the team will need sufficient information in all areas discussed above. If there is insufficient information to make these determinations, further investigation of the impact site would be conducted to collect relevant information to aid in the decision making process.

The first major decision point is to determine whether it is safe for personnel to access the impact site. If the natural location of the impact site is deemed too hazardous for personnel to enter/operate (e.g., side of a cliff), the object would be left in place and duly noted in the database. The second major decision point is to evaluate both the environmental and cost impacts of executing the recovery operation. If there is minimal environmental impact of retrieving an object and reasonable cost associated with doing so, recovery would be performed as soon as practicable. If this is not immediately obvious, an analysis considering both environmental impact and cost will be conducted. Both are equally relevant considerations that must be evaluated before the decision is made to execute a recovery operation. For example, if recovering this one object would exhaust available funds due to the extremely difficult nature of the operation, it would make logical sense to allocate the funds to recovery of several other objects that may be pending. Regardless, all located objects will be tracked in the database and logical decisions on when and how to recover will be made in consideration of the larger context of all downrange lands and NASA's commitment to providing a "clean range."

The third major decision point is whether the impact site can be mitigated in the event the decision is made to forego a full recovery operation. Impact site mitigation may entail burial of the object, partial recovery, or other activity deemed appropriate to mitigate its effects. Again, these decisions will be situation-specific and made in consultation with the respective landowner. However, the following standard operating principles will guide the recovery process.

- Employ the least invasive recovery tools as the situation dictates;
- Clean all tools of soil and plant material before leaving site to prevent the spread of invasive species;
- Give priority to locating and removing electronic components which could contain batteries or other potentially hazardous materials;
- All fins, wires, and related debris dispersed about the impact site shall be collected and removed;
- If left in place, the embedded item shall be severed such that it is does not protrude above the ground surface, as practicable; and

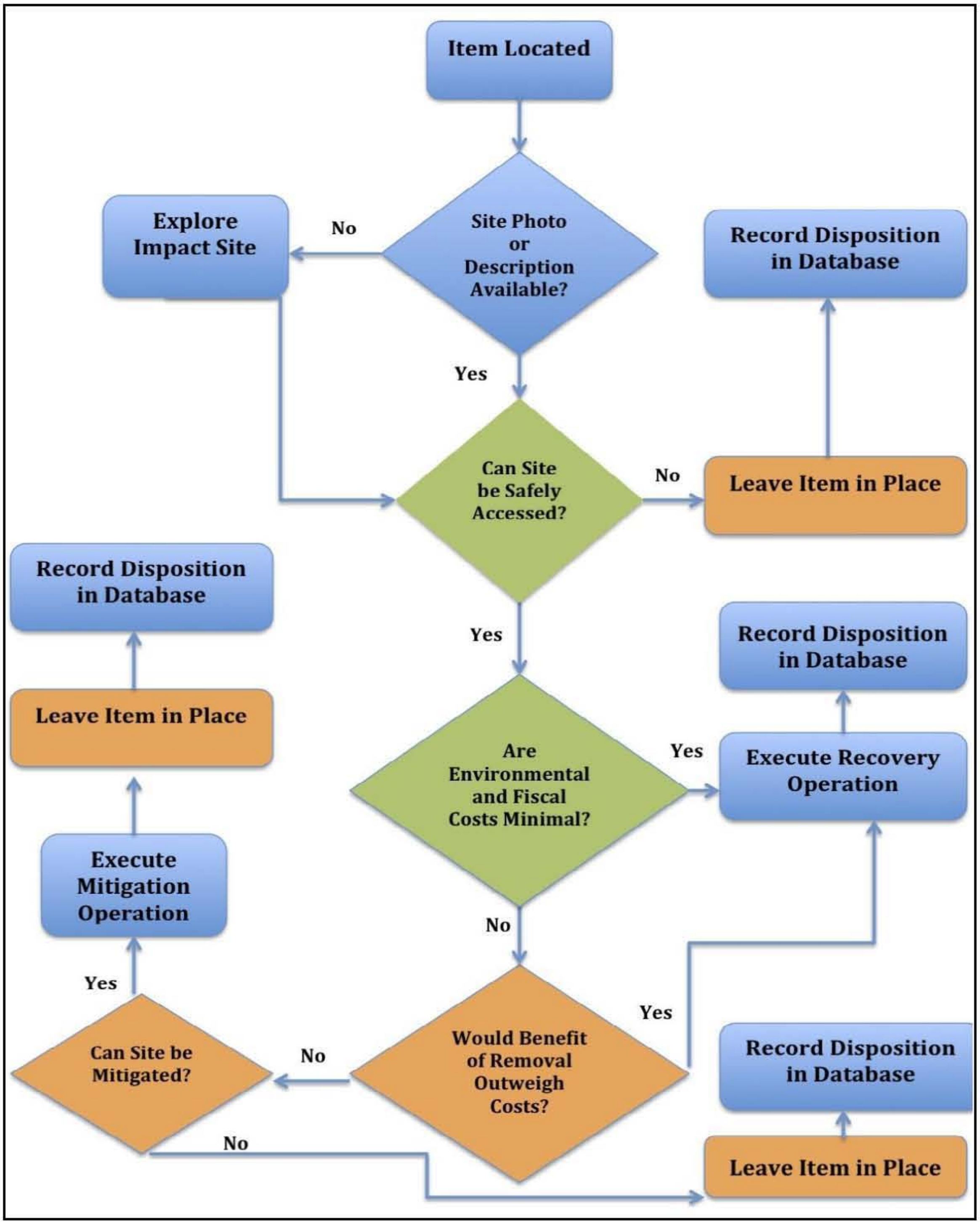
- The impact site and any remaining embedded hardware shall be backfilled with native material (e.g., soil, rock) before recovery crew departure.

While not anticipated, the potential exists for a recovery operation to be needed within a designated Wilderness area. If this were to happen, extensive coordination would be required with the respective landowner due to restrictions on helicopter landings and a requirement to utilize the minimum tools necessary to accomplish the task. Items within designated Wilderness will rank as NASA's highest priority for recovery.

The following flow chart summarizes the recovery decision-making process (see **Figure 3**), throughout which the landowner would be involved.

3.3 DISPOSAL OF RECOVERED HARDWARE

The disposal of recovered hardware will be managed by UAF. All hardware recovered will be taken to the PFRR and temporarily stored until proper disposal in accordance with applicable regulations. For the most part, this will consists of scrap metals and associated "rocket parts" and will be of a non-hazardous nature. Those materials classified as hazardous (e.g., asbestos-containing insulation, nickel-cadmium batteries) will be handled and disposed of in accordance with applicable Federal, state, and local regulations (e.g., Comprehensive Environmental Response, Compensation, and Liability Act **(42 U.S.C. 9601 *et seq*.)** and Resource Conservation and Recovery Act **(42 U.S.C. 6901 *et seq*.)**.



***<u>Green</u> shapes indicate landowner <u>consultation</u> required; <u>orange</u> indicates landowner <u>approval</u> required before proceeding*

Figure 3. Recovery Process Flow Diagram

4.0 OUTREACH AND RECORDKEEPING

4.1 OUTREACH

A key component of ensuring the effectiveness of this program and to best leverage the "eyes and ears" of users of downrange lands is to establish and maintain active public outreach efforts.

Accordingly, at least two weeks prior to the opening of a launch window, UAF will post a notice in local media (e.g., newspaper) to inform the public of the upcoming launch. Concurrently with publishing this notice, UAF will provide downrange landowners a mission "fact sheet" that includes a brief summary of the mission's objectives, the launch vehicle and recovery aides to be used, a map and location of the planned impact points, and span of the launch window. Included with this fact sheet will be a list of any onboard materials that could be potentially hazardous. Material Safety Data Sheets (MSDS) for such materials will be kept on file at the PFRR launch site, and will be provided to landowners upon request. An example of a mission fact sheet is included as **Appendix A**. Prior to launch; UAF will also post notices of the planned launch at all trailheads within the White Mountains National Recreation Area as directed by BLM.

Each year, by June 1 (the approximate start of the "snow free" season), UAF will distribute a handout (similar to that shown in **Appendix B**) to all local commercial aircraft companies, the local chapter of the private pilots association, and local guides. The purpose of this handout will be to remind aviators and guides of the rewards program and the process to follow should either a staff member or client encounter a suspected piece of flight hardware. This same handout will also be distributed to all Alaska Native Village Councils within and adjacent to the PFRR flight corridor.

4.2 RECORDKEEPING

UAF will maintain an up-to-date database to compile data regarding rockets launched and the locations at which the objects return to earth. The primary purpose of the database is to ensure all relevant data is gathered and stored in one central location. Data from past launches will be imported to the greatest extent possible. The database allows entry of the following information:

a. Rocket type, number of stages, date and time of launch
b. Predicted impact location of each stage, payload or subpayload
c. Actual impact point from radar or GPS (if available)
d. Predicted ballistic impact points from post-burn out analysis (if available)
e. Date, time, and name of landowner representative contacted
f. Type of aircraft used for search and recovery
g. Confirmation of objects located including latitude and longitude
h. Final disposition of located items
i. Reward monies paid (if applicable)

Any objects located will be photographed; their GPS coordinates logged, and any adjacent identifying landmarks noted and photographed as they may assist in recovery planning/operations. All information contained within the database will be made available to downrange landowners upon request.

4.3 REPORTING

UAF will submit a report to downrange landowners on an annual basis detailing the extent of its launch and recovery operations for the previous year. This report will include inputs to the aforementioned database and a summary of recovery operations for each rocket launched and historic items reported by users of downrange lands. Additionally, as NASA evaluates new methods for locating flight hardware, the results of these efforts will be provided.

5.0 CONTINGENCY OPERATIONS

By the very nature of sounding rockets, hazardous systems are often flown that may occasionally malfunction, therefore presenting a potential safety hazard on the ground. It is NASA and UAF policy to ensure no acutely hazardous hardware is unaccounted for following such an unplanned event. For example, through either interpretation of telemetry data or visual inspection, it may be evident that either a high-pressure gas system did not vent its contents or a pyrotechnic device did not perform its intended function (e.g. deploying a door). In these cases, NASA has developed procedures where trained technicians are deployed to the impact site to restrain and "safe" the electronically activated pyrotechnic system or to manually vent the contents of the high pressure gas system.

Furthermore, in some cases it may be necessary to immediately initiate recovery actions to mitigate a particular hazard. For example, following the failure of a Terrier-Orion flight in March 2003, NASA enlisted specialists from the Air Force's Explosive Ordinance Disposal team to puncture the payload's trimethyl aluminum canister before PFRR crews returned the second-stage motor and payload debris back to the range via helicopter for analysis. In such cases, landowners will be notified as soon as practicable and apprised of the situation and the proposed final disposition of the item. Landowners will have the final approval over proposed remedies prior the issue being considered "closed." Further coordination will be implemented as the dictated by the situation.

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APPENDIX A

EXAMPLE LANDOWNER LAUNCH NOTIFICATION

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Poker Flat Research Range
Downrange Landowner Mission Summary Sheet

Mission: Powell 36.273 UE; Cornell University

The MICA (Magnetosphere-Ionosphere Coupling in the Alfvén resonator) mission will measure ion temperature and density, electron temperature and density, electron precipitation, ion upflow, convection and ULF electric fields, magnetic fields from which field-aligned current (FAC) can be inferred, and plasma waves. The objectives of the experiment are to investigate the role of active ionospheric feedback in the development of large amplitude and small scale electromagnetic waves and density depletions in the low altitude (< 400 km), downward current, auroral ionosphere.

Launch Window: 2/13/12 – 3/1/2012; 7pm-2am local time
Launch Vehicle: Black Brant IX
Planned Impacts: First Stage 65.1411; -147.4831
Second Stage 68.0250; -146.7470
Location Aides: GPS receiver on payloads; C-band transponder on main payload
Hazardous Materials: Ni-Cd batteries on motors and main payload.
MSDS available upon request

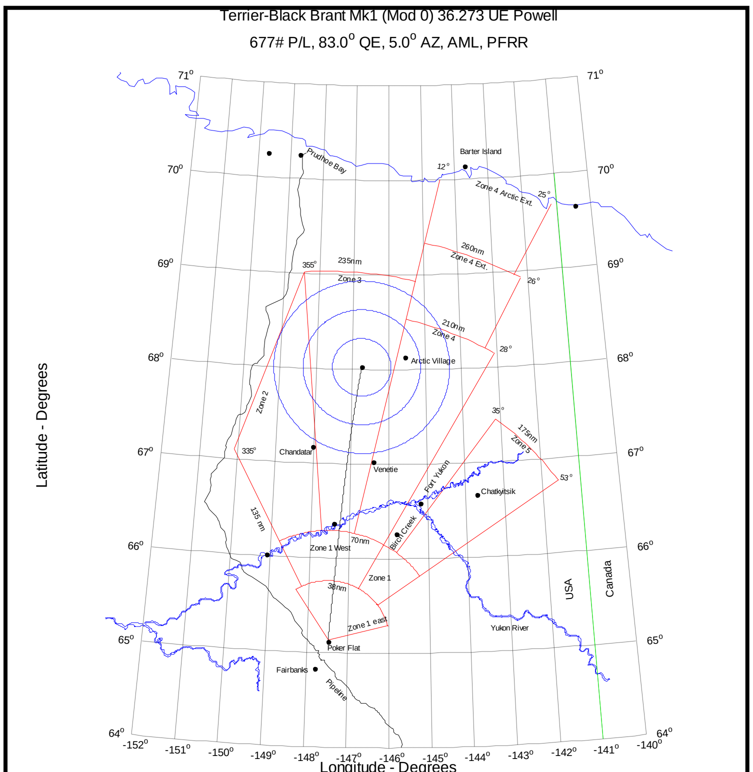

Figure 3.5-1. PFRR Impact Map

APPENDIX B

EXAMPLE PUBLIC OUTREACH FLYER

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WANTED

SOUNDING ROCKET LOCATIONS

REWARD

$1,200 FOR ROCKET MOTORS (PICTURED)

$500 FOR OTHER ITEMS

CALL (907) 455-2110

WHAT TO PROVIDE:

1. **GPS COORDINATES**
2. **PICTURE OR DESCRIPTION OF ITEM**

PLEASE DO NOT TOUCH ANYTHING!

SOME ITEMS MAY BE DANGEROUS
REPORT IT AND WE WILL REMOVE IT
THANKS FOR HELPING US KEEP THE LANDS CLEAN!

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