APPENDIX 7-A

Emergency Response Plan

Executive Summary

Introduction

This emergency response plan has been prepared to provide site management and emergency response team members with a general guideline of the expected initial response to an emergency and an overview of their responsibilities during an emergency.

For this plan to be effective, it is important that all personnel who have a role in the plan be made aware of its provisions and that everyone be prepared to carry out their assigned functions and responsibilities in an emergency.

Background

The Saskatchewan Regulations requires employers to take all reasonable precautions to prevent fires in the workplace and to develop plans to deal with fires in the workplace. It also states designated persons and workers who have assigned duties be adequately trained in the implementation of the plan.

Highlights of the Plan

This emergency response plan deals with the following types of emergencies:

- medical emergencies, both occupational and non-occupational
- fire
- environmental emergencies
- underground emergencies

As with any emergency response plan it is impossible to cover all possible scenarios of what could happen at the Shore Gold site. However all emergencies must have an organized response to the emergency to bring the situation under control in a timely manner and restore the operation to normal as soon as possible. This is accomplished by assigning responsibilities to key management positions and by training emergency response personnel. In addition to assigned responsibilities it is important to test the plan with both field exercises and tabletop exercises. This is the most efficient way to train personnel on their roles. The plan must also be reviewed on a regular basis and updated as required. This plan contains elements that ensures the above mentioned activities are carried out on a regular basis.

Another crucial element of this plan is the mutual aid agreements that are in place with other emergency response organizations in our area. Shore Gold is at the early stages of development and as such is dependent upon outside resources to provide assistance during emergency situations. These outside emergency response organizations must be given opportunities to view the Shore Gold site so they can carry out planning should they be required to respond to an emergency at the site.

Section 1 – IMMEDIATE ACTIONS

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EMERGENCY MEDICAL PROCEDURE

In the event that an injury or illness has occurred and an EMT is required, the following procedure is to be followed.

Action	Responsible Person
1. Take Charge of the situation	Person finding the ill or injured person(s)
2. Contact Star Gate Security by radio on either channel 1 or 2 Or by phone at 1-306-230-1527 - state your name - your location - the location of the emergency - the nature of the emergency - if there are injuries, how many - ask the security person to repeat the information back to you - administer first aid if trained to do so - remain in the area until the emergency response personnel arrive so you can direct them to the casualties	Person finding the ill or injured person(s)
Star Gate Security will Broadcast on Both Radio Channels the following Message: ***Code 1, Code 1 Code 1*** ***Medical emergency at (state location)*** ***I repeat Code 1, Code 1, Code 1*** ***Medical emergency at (state location)*** ***This is Shore Gold Security standby for further broadcasts***	**Star Gate Security**

Fire Procedure

Action	Responsible Person
1. Take Immediate Action. The safety of you and your fellow workers is the top priority	Everyone
2. Sound the Alarm or Air Horn to notify other workers in the area	Person finding the fire
3. Call Star Gate Security by radio on either Channel 1 or 2 or by phone at 1-306-230-1527 - state your name - your location - tell them you are reporting a fire	Person finding the fire or another co-worker in the area
4. Attempt to fight the fire but only if safe to do so. **DO NOT ENDANGER YOURSELF OR OTHERS. MAKE SURE YOU HAVE A SAFE EXIT FROM THE BUILDING AT ALL TIMES**	All personnel in the area
5. Star Gate Security will Broadcast on Both Radio Channels the following Message: ***Code 1, Code 1 Code 1*** ***Fire Emergency at (location)*** ***I repeat Code 1, Code 1 Code 1*** ***Fire Emergency at (location)*** ***This is Shore Gold Security*** ***stand by for further broadcasts***	**Star Gate Security**

Mine Emergency Procedure

Action	Responsible Person (RP)
1. Take Immediate Action	
2. Upon detection of an underground emergency notify the Hoist person immediately. Assess the situation and take appropriate action, fight the fire if safe to do so, administer first aid if trained, notify workers in immediate area, proceed to refuge station if in immediate danger.	Person finding incident
3. Hoist person shall notify Security. In the event of a fire or other life threatening situation the hoist person will release the stench gas into the mine.	Hoist person
4. Security will Broadcast on Both Radio Channels the following Message: ***Code 1, Code 1 Code 1*** ***Emergency at Location*** ***I repeat Code 1 Code 1 Code 1*** ***Emergency at Location*** ***This is Shore Gold Security stand by for further broadcasts***	Security

Environmental Emergencies

Actions	Responsible Person
1. Take Immediate Action. The safety of you and your fellow workers is the top priortiy	**Everyone**
2. Call Star Gate Security by radio on either Channel 1 or 2 or by phone at XXX-XXXX - state your name - your location - tell them you are reporting an environmental emergency - tell them what the nature of the emergency is i.e. spill	**Person finding the environmental emergency**
3. Attempt to contain the spill by building earthen dykes around it. Only do so if it can be done safely. Do not endanger yourself or others.	**Person finding the environmental emergency**
4. Attempt to plug/stop the spillage. Only do so if it can be done safely. Do not endanger yourself or others	**Person finding the environmental emergency**
Code 1, Code 1, Code 1 Environmental Emergency at (location) **I repeat Code 1, Code 1, Code 1 Environmental Emergency at (location)** **The is Shore Gold Security stand by for further broadcasts**	**Star Gate Security**

IMMEDIATE CONTACT LIST

1.1 INTERNAL CONTACTS

Shore Gold Site
FAX:

Role	Primary	First Alternates	
Project Manager			
Assistant Project Managers			
Security			
SUPPORT STAFF			
Environmental Coordinators			
Site Services Foreman			
Safety Officers			

FIELD STAFF			
Incident Commander		Most senior management person on-site at the time of the emergency	
ERT Captain		Assigned from available fire team members on-site at the time of the emergency	
EMT	On – Duty EMT		Site First Responders
SASKATOON CORPORATE OFFICE			
PRIMARY	**PHONE**	**BACKUP**	**PHONE**

1.2 EXTERNAL CONTACTS

AGENCY	PHONE NUMBER	
	Bus. Hours	24 Hours
EMERGENCY SERVICES		
RCMP – Smeaton Detachment RCMP – Prince Albert	N/A	1-306-426-2630 1-306-765-5500
Sask Environment Project Officer – Nipawin **SPILL CONTROL CENTRE**		 1-306-862-1790 1-800-667-7525
Forest Fire Control Centre	306-953-2691	1-800-667-9660
Parkland Ambulance	306-953-9804	1-306-953-9804
NEIGHBOURING COMMUNITIES AND OPERATIONS		
Choiceland	306-428-2070	
Smeaton	306-426-2044	
SERVICES AND UTILITIES		
Sask Power		306-310-2220
Sask Tel	306-425-6315	611
ESSO Petroleum Emergency Hotline	1-519-339-2145	
Transwest Air		306-633-2022
TRANSPORTATION RESOURCES		
CANUTEC (Canada) (Call Collect) – Cell Phone	N/A	613-996-6666 Ext. 666
Chemtrec (USA)		1-800-424-9300
GOVERNMENT REGULATORY AGENCIES		
Provincial		
Sask. Environment – Site Project Officer	306-862-1790	N/A
Sask. Labour – Mine Inspector	306-933-7594	1-800-667-5023
Federal		
Environment Canada	306-780-6390	416-346-1971
Canadian Coast Guard	403-780-6390	
Department of Fisheries and Oceans	306-953-8787	
CHEMICAL SUPPLIES		
Available electronically and in print form at MSDS stations	N/A	N/A

Section 3 - ORGANIZATION

3.1 SHORE GOLD SITE CRISIS MANAGEMENT TEAM (SCMT)

3.1.1 Function

The Site Crisis Management Team is situated on the Shore Gold site and operates from the Command Centre located in the main board room in the administration building.

3.1.2 Staffing

See Section 1 and organizational structure in Figure 3.2. Various roles will be activated by the Manager, depending on the nature and severity of the incident.

3.1.3 Location

Provide an organized response to an emergency or crisis involving company personnel or assets related to the Project. The Site Crisis Management Team also provides a communication link to the Corporate Crisis Communication Team in Saskatoon.

3.2 EMERGENCY RESPONSE TEAM (ERT)

3.3.1 Function

Provide hands-on response to emergency situations at the Shore Gold site. Emergency Response teams may also be called upon to respond to off site emergencies.

3.3.2 Staffing

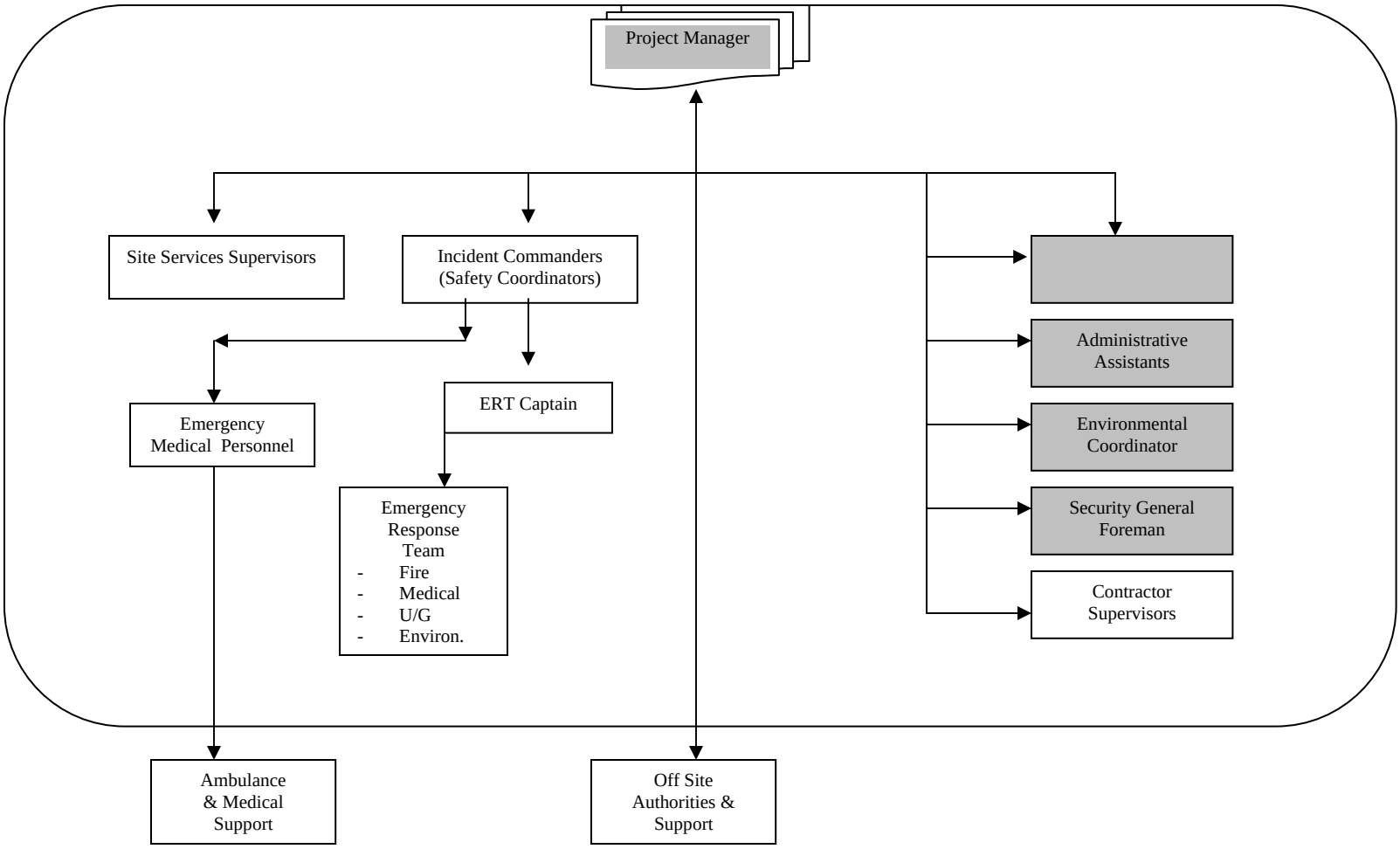
See Section 1 and organizational structure in Figure 3.2.

3.3.3 Location

Field Operations are located at the emergency site of the Shore Gold site or the off-site emergency.

3.2 CORPORATE CRISIS COMMUNICATION TEAM

To be determined prior to construction.


Project Manager
Site Services Supervisors
Incident Commanders (Safety Coordinators)
Administrative Assistants
Environmental Coordinator
Security General Foreman
Contractor Supervisors
Emergency Medical Personnel
ERT Captain
Emergency Response Team
- Fire
- Medical
- U/G
- Environ.
Ambulance & Medical Support
Off Site Authorities & Support

SECTION 4 – ALARMS / ALERTING

4.1 ACTIVATION	
	In the event of an emergency, the alarm system is activated by any person from a pull station, automatic alarm system activation, calling Security personnel by phone or radio or under the direction of an ERT member. The Assistant Project Manager, in consultation with the Incident Commander, determines the level of the emergency and commences notification as required.

4.2 DEFINITIONS OF EMERGENCY LEVELS	
4.2.1 **GENERAL**	An emergency is a situation that presents danger to the safety of site personnel, the general public and/or the environment. Immediate action is necessary to bring the situation under control. The problem cannot be dealt with using normal operating procedures.
4.2.2 **LEVEL I**	Minor Incidents such as non-reportable release, first aid, or small release of material that does not leave the site requires no support from corporate
4.2.3 **LEVEL II**	Moderately serious incidents such as a small release or an injury requiring medical treatment at a medical facility, a release of material that moves off site but does not present a safety hazard to the community.
4.2.4 **LEVEL III**	Most serious incident such as an explosion, serious injury, fatality, or a major release of material off site that presents a significant safety hazard to the community.

4.3 ALARM DESCRIPTION	
4.3.1 **ALL EMERGENCIES ALERT**	Camp is equipped with standard fire bell alarms. All other areas use the compressed air horns to alert employee's Security announces the emergency on both radio channels
4.3.2 **ALL CLEAR**	The Project Manager orders the stand down in consultation with the Incident Commander.
4.3.3 **SITE EVACUATION**	Mainly due to forest fire threat and would be coordinated by radio, telephone and ERT sweep of operation areas.

4.4 ACTIONS ON ALARM	
4.4.1 **SITE CRISIS MANAGEMENT TEAM**	Mobilize the Incident Commander, ERT as a minimum for any emergency alert. Incident Commander conducts an assessment of the situation and impacts Activate the Emergency Response Plan as described herein.
4.4.2 **ALL OTHER PERSONNEL**	Respond to the alarms and follow the instructions of the Site Crisis Management Team. Take charge of visitors or contractors assigned to them or delegate this function.

SECTION 5 – DUTIES AND RESPONSBILITIES

5.1 SHORE GOLD EMERGENCY RESPONSE ORGANIZATION

5.1.1 ASSISTANT PROJECT MANAGER/DESIGNATE	
LOCATION:	At the Administration Command Centre.
PRIMARY:	
FIRST ALTERNATE:	
SECOND ALTERNATE:	
ROLE:	Control and coordination of Shore Gold's response to emergencies on or near the site.
RESPONSIBILITIES:	↓ Respond to the command centre, as required. ↓ Overall control of the Shore Gold site during an emergency situation. ↓ Ensure planning takes protection or isolation of utility services into account. ↓ Direct that the following resources be notified and dispatched, as required ↓ Environment Coordinator ↓ Site Services supervisors Provide first line communications with the Corporate Crisis Communication Team as required. Approve release of all information from Shore Gold's site. Mobilize other resources as warranted by the emergency (eg. Maintenance personnel to assess continued operation of site utilities). Evaluate broad impacts of emergency on: Worker and Public Safety Environment Company Property Company Image Develop strategic planning in relation to emergency. In consultation with the Incident Commander, determine and direct termination of emergency response operations when incident has been rendered safe. Provide resources for equipping and training emergency personnel to meet response objectives. Maintain a written record of all activities

SECTION 5 – DUTIES AND RESPONSBILITIES

5.1.2 SAFETY COORDINATOR - INCIDENT COMMANDER	
LOCATION:	At the emergency site.
PRIMARY:	
FIRST ALTERNATE:	Most senior supervisor on site at the time of the incident
SECOND ALTERNATE:	Assigned by command centre
ROLE:	Primary authority for all field operations in an emergency.
RESPONSIBILITIES:	Locate and evaluate situation. Contact ERT Captain. Coordinate immediate resource requirements. Communicate needs and updates to Assistant Project Manager Mobilize overall control of field operations. Direct mobilization of outside resources. Coordinate field activities of Shore Gold Responders with off-site resources. Delegate duties / responsibilities to appropriate personnel to handle emergencies such as spill response, triage and fire fighting. Request or initiate evacuation in consultation with the Manager. Ensure field access (crowd) control using the Site Services personnel or other support.

SECTION 5 – DUTIES AND RESPONSBILITIES

5.1.3 Site Services Supervisor	
LOCATION:	Shore Gold's Command Centre
PRIMARY:	
FIRST ALTERNATE:	As assigned
SECOND ALTERNATE:	
ROLE:	Provide support to Manager and Incident Commander through the acquisition and management of materials and expertise.
RESPONSIBILITIES:	Recruit and brief support personnel to ensure they are aware of situation, as directed by the Assistant Project Manager. Direct dispatch of resource to the field when asked for. Ensure that resource status is maintained (who and what is where). Work with Assistant Project Manager to plan support for the Incident Commander. Work with Assistant Project Manager to develop recovery plans. Implementation of recovery plans as directed by the Assistant Project Manager..

SECTION 5 – DUTIES AND RESPONSBILITIES

5.1.4 Administrative Assistants	
LOCATION:	At the Shore Gold's Command Centre
PRIMARY:	
FIRST ALTERNATE:	
SECOND ALTERNATE:	
ROLE:	Directs all telephone, internet and air traffic at the Shore Gold site during and following an emergency situation.
RESPONSIBILITIES:	Set up command centre as directed by Assistant Project Manager Document, in chronological order, events as they occur during they emergency (digital photos as necessary). Direct air traffic (helicopter medivacs) as required. Ensure office supplies are replenished in command centre as they are consumed. Collect all records and logs of event for the purpose of post-incident review and debrief. Maintain a written record of all activities (See sec. 9 Form 1 – Time and Event log).

SECTION 5 – DUTIES AND RESPONSBILITIES

5.1.5 ENVIRONMENTAL COORDINATOR	
LOCATION:	At the Shore Gold Command Centre
PRIMARY:	
FIRST ALTERNATE:	
SECOND ALTERNATE:	
ROLE:	Provide environmental monitoring services and technical advice during an emergency operation as required; and assist ERT in an off-site spill response.
RESPONSIBILITIES:	Initially, respond with the Assistant Project Manager to the command centre. Provide monitoring for environmental impact at the direction of the Assistant Project Manager. Advise Assistant Project Manager or Incident Commander of monitoring results and the potential impacts. Ensure impacts are minimized from an on site spill and contaminated material disposed of in accordance with appropriate environmental procedures. Maintain a written record of all activities (See sec. 9 Form 1 – Time and Event log).

SECTION 5 – DUTIES AND RESPONSBILITIES

5.1.6 EMERGENCY RESPONSE TEAM CAPTAIN	
LOCATION:	At the emergency scene.
PRIMARY:	As assigned
FIRST ALTERNATE:	As assigned
SECOND ALTERNATE:	As assigned
ROLE:	Provide leadership to the ERT in emergency situations to ensure the safety of the team while providing the most effective response to an emergency.
RESPONSIBILITIES:	Meet at Muster Point and mobilize team as instructed by the Incident Commander. Report to the scene and report to the Incident Commander for instruction. Ensure safety of the ERT at the scene as well as to and from the scene. Supervise and assign duties of the ERT at the scene including scene safety, triage, patient care, security and transportation in consultation with the Incident Commander. Coordinate fire-fighting effort. Provide fire related technical support for the ERT in the event of a fire. Coordinate confined space rescue and hazardous material spill response. Monitor operator use of fire equipment to ensure it is being used safely.

SECTION 5 – DUTIES AND RESPONSBILITIES

5.1.7 EMT	
LOCATION:	At the Administration area First Aid center.
PRIMARY:	EMT's
FIRST ALTERNATE:	Site First Responders
SECOND ALTERNATE:	
ROLE:	Provide Medical Aid support to injured personnel, as required.
RESPONSIBILITIES:	Respond to the health centre unless otherwise directed by the Incident Commander. Prepare health centre as warranted by emergency situation. Request more first aid assistance from the Incident Commander if needed. Arrange for ambulance by contacting the front gate security personnel Assist RCMP or regulatory agencies with investigation of emergency if requested. Arrange for MSDS sheets to accompany medivac patients or fax to hospital if required. Brief Assistant Project Manager as to status of injured personnel in order that the next of kin/family can be contacted as necessary. Arrange for clean up of biomedical waste at the emergency scene and treatment centre after care for the injured has been provided. Maintain a written record of all activities (See sec. 9 Form 1 – Time and Event log). Ensure that patient care is documented and is retained.

SECTION 5 – DUTIES AND RESPONSBILITIES

5.1.8 Security Personnel	
LOCATION:	Security
PRIMARY:	Security personnel
FIRST ALTERNATE:	Mill security personnel
SECOND ALTERNATE:	
ROLE:	Site communications and notifications
RESPONSIBILITIES:	Broadcast Emergency notification on all channels upon notification of an emergency Contact EMT in camp for after hours emergencies Call 911 to request an ambulance if requested by the Emergency Medical Personnel. Pass on any relevant information received from the EMT to the ambulance dispatch person Announce the ALL CLEAR over all radio channels once directed to do so by the Assistant Project Manager or their designate. Contact off-site personnel to come to the site if required

SECTION 5 – DUTIES AND RESPONSBILITIES

5.1.9 Mine Rescue Coordinator	
LOCATION:	At TMCC Site Office
PRIMARY:	
FIRST ALTERNATE:	
SECOND ALTERNATE:	
ROLE:	Develop and implement search and rescue plan for underground
RESPONSIBILITIES:	Respond to the TMCC Site Office Account for all personnel working underground Call Shore Gold Command Centre and inform them of the personnel count Work in conjunction with Shore Gold SCMT to develop and implement a response plan. Brief Mine Rescue team before they enter the mine Maintain contact with the Mine Rescue Captain and update SCMT.

SECTION 5 – DUTIES AND RESPONSBILITIES

5.1.10 Mine Rescue Captain	
LOCATION:	Mine Rescue Trailer
PRIMARY:	As assigned
FIRST ALTERNATE:	As assigned
SECOND ALTERNATE:	
ROLE:	Carry out search and rescue operations in the underground mine
RESPONSIBILITIES:	Respond to the Orion South Mine Rescue Trailer Assemble two - three person team's and bench test apparatus and prepare equipment Report to Mine Rescue Coordinator when initial entry team and back up team are prepared to enter the mine Brief the Mine Rescue team on the objectives SAFETY OF THE TEAM IS THE NUMBER 1 PRIORITY Enter the mine and carry out the objectives Report back to the fresh air base on a regular basis and inform the Coordinator of progress made and any findings

SECTION 6 – SPECIFIC FUNCTIONS

6.1 EVACUATION	
6.1.1 ACTIVATION	Evacuation will be conducted under the following conditions: ↓ At the direction of the Assistant Project Manager and/or Incident Commander ↓ A fire, spill or other event that forces abandonment of the buildings ↓ At the direction of the Forest Fire Control Centre or RCMP
6.1.2 PROCEDURE	Upon receipt of direction to evacuate from the Assistant Project Manager for a local emergency, all personnel will: Leave the buildings immediately. Close but do not lock doors. Proceed to the designated assembly areas (camp, administration helicopter pad) and report to their supervisors. Camp manifest print outs will be reviewed to ensure that all personnel are accounted for. Wait at the evacuation assembly area until advised that it is safe to return to the building or to leave the site. The Incident Commander will make a decision when to return followed by a "Return To Work" OR "All Clear" announcement. During inclement weather, all non-response personnel are to remain at assembly areas or at an alternate location to be chosen at the time of the incident. Note that emergency vehicles have the right of way in all instances. If the Shore Gold site is ordered to be evacuated by the Assistant Project Manager all personnel except those assigned to maintain critical systems will: Shut down equipment and work areas as directed by each employee's supervisor. Leave buildings but do not lock doors. Proceed to the emergency gathering points and report to appropriate supervisor. Camp manifest print outs will be reviewed to ensure that all personnel are accounted for who are staying in camp. Wait at the emergency gathering points until advised that it is safe to return to work or to leave the site. The Assistant Project Manager will make a decision when to return followed by a "Return To Work" announcement. During inclement weather, all non-response personnel are to remain at assembly areas or at an alternate location to be chosen at the time of the incident. Note that emergency vehicles have the right of way in all instances. Details of the evacuation process will be provided at the time of evacuation by the Assistant Project Manager or his designate.

SECTION 6 – SPECIFIC FUNCTIONS

6.2	**PUBLIC AFFAIRS / MEDIA RELATIONS**	
6.2.1	**PURPOSE**	All site communications during an emergency will controlled by the Corporate Crisis Communication Team
6.2.2	**RESPONSIBILITY**	Public Information is the responsibility of the Corporate Office.
6.2.3	**MEDIA PROCEDURES**	The Public Relations Coordinator of the Corporate Crisis Communication Team will handle Media Relations activities for the Shore Gold site with assistance from the on site Assistant Project Manager. Any employee approached by the media will direct them to the senior employee on site.
6.2.4	**INFORMATION KITS**	Information kits explaining the Shore Gold operation and the emergency response procedures will be developed as part of the CCCT response if necessary.
6.2.5	**PUBLIC PROCEDURES**	Inquiries from the general public will be directed to the CCCT.

6.3	**OFF SITE RESPONSE TO EMERGENCIES**	
6.3.1	**OFF SITE RESPONSE**	The RCMP and/or Saskatchewan Environment have jurisdiction and are in charge of any off site emergency scene. Requests to supply technical advise to an off site response operation will be evaluated at the time of the request by the Corporate Crisis Communication Team. Consideration will be given to the nature of the request and activity status of the Shore Gold site. The Shore Gold Emergency Response Team will respond to off site emergencies if so directed by the Assistant Project Manager or the Corporate Crisis Communication Team. The Shore Gold Emergency Response Team would function in a first responder (HAZMAT, medical or environment) capacity or technical advisory capacity.

SECTION 6 – SPECIFIC FUNCTIONS

6.4 COMMUNICATIONS	
6.4.1 RADIO	Hand-held, portable two-way radios are one of the two prime means of communications. These radios are for local area communications within the facility and the immediate area. Base stations are located in the Security Main Gate, Security Office at the plant, the JV Core Storage area. The radio operate on two channels: • Channel 1 Shore Gold • Channel 2 Weyhauser
6.4.2 TELEPHONE AND FAX	The Shore Gold site is equipped with a SaskTel telephone system and a large number of cell phones. The Administrative Assistants may be requested to fax or pdf documents.
6.4.3 RUNNERS	May be used to obtain first hand information.

6.5 BOMB THREAT	
6.5.1 THREAT BY TELEPHONE	When a bomb threat is received by telephone, the person receiving the call will: • **Listen** • Be **Calm** and **Courteous** • **Do Not Interrupt** the caller • **Obtain** as much **information** as you can from the caller • **Notify** another person on site if you can. Preferably do this while the caller is still on the line
6.5.2 EVALUATING THE THREAT	In general, it has been found that a real bomb threat has several characteristics. • It is almost invariably the worked of a deranged person • The bomber, in placing the call, tends to prolong the call and is willing to furnish some details as to the location of the device, reasons for planting it, etc. • The call is often repeated On the other hand, a prank caller • Tends to be abrupt and hurried in giving the message and seldom can or will provide details regarding the type of device, location, etc. • Less frequently repeats the call because of fear of tracing, etc.

	All bomb threats, genuine or otherwise, will be documented and reported to the RCMP and Shore Gold's management for follow-up.
6.5.3 RESPONDING TO A TELEPHONE THREAT	Once it has been established that a bomb threat is genuine, the following actions must be taken. • Contact Assistant Project Manager or designate • Assistant Project Manager contacts the RCMP • Evacuate affected personnel to a safe distance • Search the premises. The extent of the search will be determined by the evaluation of the threat • If a bomb is not discovered in the search, wait until the time frame for the bomb to detonate has passed • If a bomb is discovered, DO THIS; *Isolate the immediate area* *Do not attempt to touch or disarm or to move the device or suspicious package* *Assist Police as required*
6.5.4 SUSPICIOUS PACKAGE	Whenever a suspicious object is found that cannot be accounted for, it should be reported immediately to the employees' supervisor. This information must also be communicated to the Assistant Project Manager. **UNDER NO CIRCUMSTANCES SHOULD YOU TOUCH OR TRY TO MOVE THE PACKAGE!** DO THIS: • Check to see if the object can be accounted for • Notify others in the area • Assistant Project Manager to notify the RCMP and Shore Gold Corporate office • Evacuate the immediate area • Await further instructions from the RCMP
6.5.5 SHUTDOWN/EVACUATION	Apart from the cost involved, a hasty evacuation in response to a bomb threat may invite "copy cat" threats. Accordingly, unless there is some reason to believe a threat is valid, evacuation should not be considered the automatic response to a bomb threat. In the event an evacuation is necessary, proper emergency shutdown procedures will be followed. The will minimize the possibility of causing other problems.
6.5.6 NOTES	The average number of words in a bomb threat call is 8-17. We need more information and more time to trace the call. As you ask the questions listed on the report form, attempt to collect all of the impressions and information about the caller that you can. These include such items as male – female, old – adult – teenager, foreign or localized accent, illiterate – intelligent, peculiar or personal speech defect (lisp, stutter,

	etc) tone (high, fast, bass, etc.) and temper (angry, vindictive, joking, etc). Also listen or note any noticeable or predominant background noise such as heavy traffic, low flying aircraft, trains, construction activity, loudspeakers, cheering crowds, etc. To the extent possible, write the exact words spoken by the caller in response to these questions immediately while recall is fresh. Note also which line the call is on, and if possible whether local or long-distance. Immediately notify the Safety Department and your supervisor, etc, get a fellow employee to summon your supervisor and attempt to keep the caller on the line.

6.6 ACCIDENT SCENARIOS

Propane Vapor Leak

The three main hazards from a leak in the propane transfer line are gas exposure, fire/explosion and frost bite. The zone of influence would be less than 100 m.

A more serious scenario would be if the leak occurred on a line at one of the large propane tanks. The zone of influence for such a scenario would be up to 400 m.
The environmental impact would be minimal because the propane vapor would dissipate in the atmosphere.

Gasoline Line Leak

The two main hazards from a leak in the gasoline transfer line are fire/explosion and environmental contamination. The zone of influence would be up to 200 m.

A more serious scenario would be if the leak occurred on a line in the fuelling area. The zone of influence for such as explosive scenario would be up to 400 m.
Immediate measures would have to be taken to contain the spill and minimize the environmental impact, limiting it to the immediate area of the spill.

Transportation Disaster

Shore Gold personnel are transported to and from site by First Bus on public roads. A possibility exists that a motor vehicle accident could occur which would result in a multiple casualty scenario.

Workers are transported daily from camp to the work areas on public roads. This presents another possibility of a multiple casualty emergency.

Environmental impact would depend on the severity of the accident. It would range from negligible to major impact.

6.7 ENVIRONMENTAL EMERGENCIES

This section is intended to meet the requirements for specific products as defined by the Canadian Environmental Protection Act (1999), Environmental Emergencies Regulations. These products and required additional information are provide below.

Gasoline

Environmental Emergency Potential: Gasoline is stored in an EnviroTank located just outside the main gate. The tanks have their secondary containment built in. If this containment is breached, soil contamination would occur. There are no water bodies in the immediate area that could be affected by an incident of this nature. In the event of a fire, there would be significant smoke created, however no acute or long-term environmental impacts would be expected.
Maximum amount that could be present at any time: ?? tonnes
Process Interruptions: Access to the process plant would be temporarily interrupted
Consequences to Humans: refer to MSDS

Propane

Environmental Emergency Potential: The three main hazards from a leak in the propane storage tanks and transfer systems are gas exposure, fire/explosion and frost bite. The zone of influence would be less than 100m. Propane is stored in 4 locations at the site; Mill site, camp, Orion shaft and the JV Core shack. Liquid propane is stored under pressure at these locations. Any compromises at these locations will result in pressure being released and liquid propane vaporizing. Soil contamination may be possible in the immediate location as a result of an emergency in these locations, however the larger environmental impact will be the atmosphere, which would be relatively insignificant.
Maximum Amount that could be present at any time: ??
Process Interruptions: An emergency involving propane would have a significant impact on the service area of the tank as this is the main fuel for heating the facilities.
Consequences to Humans: refer to MSDS

SECTION 6 – SPECIFIC FUNCTIONS

6.8 DELETERIOUS SUBSTANCES EMERGENCY RESPONSE PLAN

1. This section is intended to supplement the overall site emergency response plans with specific information required pursuant to *The Fisheries Act, Metal Mining Effluent Regulations* (2006).

2. Deposits of deleterious substances, outside of the normal course of events, that can reasonably be expected to occur at the Shore Gold site and that can reasonably be expected to result in damage or danger to fish habitat or fish or the use of fish by man, are as follows:

<u>Release of hydrocarbons from equipment working or located near fish habitat</u>

- Releases of fuel, lubricants, or coolant could possibly occur from heavy equipment operating near fish bearing waters. Depending on volume such releases could have localized impacts on fish and fish habitat. The Saskatchewan River is located south of the Project.

SECTION 7 – RESOURCES

7.1 INTERNAL RESOURCES	
7.1.1 EMERGENCY CONTACTS	Emergency contacts names and phone numbers for the Shore Gold site are listed in Section 1.2.
7.1.2 EQUIPMENT	The following materials and equipment are available at the Shore Gold site.
EQUIPMENT	**DETAIL**
Confined Space Rescue	
Fire Fighting	Portable fire extinguishers are located around the site
Emergency First Aid/Medical Supplies	Emergency First Aid/Medical Supplies are located in Security Building
Generator	Portable generators are located at around the site. These units can be disconnected and relocated as required.
Hazardous Materials	Spill kits are located at key locations around the site. The safety truck and environment truck are also equipped with spill kits.
Satellite Phone	??
Cell Phones	All supervisors carry cell phones
Radios	Site personnel carry two-way hand held radios. Vehicles are also equipped with two way radios.

SECTION 7 - RESOURCES

COMMAND CENTRE EQUIPMENT	
Command Centre Equipment	↓ Plasticized site plans including satellite photos of the Shore Gold exploration area (on the wall) ↓ Satellite phone (See Security Building) ↓ Hand held radios ↓ House phone (on the desk) ↓ Hand held tape recorder ↓ Blank Time/Event Log sheets ↓ Stationary supplies ↓ Phone books for Saskatoon and Prince Albert and area ↓ Shore Gold Emergency Response Plan ↓ Corporate Crisis Communication Plan ↓ Emergency Response Guide ↓ Hi-Vis traffic vests ↓ Tactical work sheet

Command Centre equipment (box) is located in the main boardroom area in the Administration building. The Administrative Assistants are responsible for completing and maintaining all inspection and maintenance records. To be inspected monthly and after each use.

SECTION 8 - RECOVERY

8.1 OVERVIEW	
	Post-incident recovery activities should be initiated as soon as possible, preferably WHILE RESPONSE OPERATIONS ARE STILL UNDERWAY. The Site Crisis Management Team will remain functional until such time as the company begins the process of restoration of facilities and routine operations. The process of evaluation will begin at the time of the crisis and the Site Crisis Management Team will conduct an after-action review. This review is conducted with a view to establishing corporate and site 'lessons learned' as well as recommending new preventative policies and procedures. Action taken during response operations should be decided, whenever possible, with post-incident recovery in mind. Recovery operations include: ↓ Repair of damaged structures. ↓ Restoration of services such as power, heat and communications. ↓ Clearing of access routes. ↓ Restore damaged units to production. ↓ Remediation.

8.2 REMEDIATION	
	Clean up of the incident site should begin as soon as possible under the direction of the Incident Commander. Should fatalities result, it will be necessary to wait until the Office of the Coroner and the RCMP release the site. Recover all contaminated liquids to a proper storage container. If contaminated material has entered secondary containment structures, then the containment structures and interconnecting piping must be cleaned if deemed necessary by the Incident Commander. Recover all contaminated soils into proper storage containers and dispose of as directed by the Environmental Coordinator. Cover contaminated area to stop rains washing contaminants further into the soil until recovery operations begin.

SECTION 8 - RECOVERY

8.3 PUBLIC RELATIONS	
	When an incident results in off-site impacts, it will be necessary to carry out public relations activities. The Corporate Crisis Communication team will be responsible for carrying out all public relations activities. The priority is to demonstrate to the public that Shore Gold is concerned for the safety of its neighbors. Public relations activities may include: ↓ Clean up of debris ↓ Meetings to inform the public about the incident's causes and what the company is doing to prevent a recurrence. ↓ Counseling services to site personnel and public affected by the incident. Representatives of news agencies may be present at the scene of an emergency involving Shore Gold personnel. Only designated spokespersons will speak to media representatives on behalf of Shore Gold. This is to ensure consistency and as much accuracy as possible when communicating with the media and through them to the public. All formal written news releases will be prepared and approved by Shore Gold Corporate head office in Saskatoon.

8.4 EMPLOYEE ASSISTANCE	
	Employees affected by the incident may experience delayed and/or long-term reactions. These effects may include: ↓ Loss of employment due to destruction of work place. ↓ Losses may be real or perceived. ↓ Critical Incident Stress. Meetings at the site can be used to inform employees about the long-term implications of the incident. It is necessary to establish the company's position on the issue of job loss and retention of employees as early in the recovery phase of the operation as possible. Critical Incident Stress Debriefings will be initiated for affected employees and their families as required or recommended by the Human Resources

8.5 LITIGATION	
	Post-incident litigation will be managed by the Corporate office. This action will be initiated through the CCCT as early as possible following an incident where a Shore Gold action has threatened or harmed a third party.

SECTION 8 - RECOVERY

8.6	**RESUMPTION OF BUSINESS**	
		An emergency may adversely affect exploration drilling and/or mill production. This effect may be felt for an extended period of time depending on the severity of the incident. Impairment may be a result of injury to personnel, damage to the exploration equipment or mill or government regulatory action. The SCMT would commence with plans to restore the exploration equipment and/or mill to normal operations as soon after the incident as possible. Some of the planning and implementation of restoration measures may commence while the emergency is still being responded to depending on the situation.

8.7	**POST INCIDENT INVESTIGATIONS**	
8.7.1	**OVERVIEW**	Every emergency involving a fatality, a serious injury, and loss or significant damage to Shore Gold property will be investigated. As soon as possible after an incident, personnel designated by senior management will mobilize and depart for the incident site to conduct an investigation into the incident. PARTICULAR CARE MUST BE EXERCISED TO ENSURE THAT ALL EVIDENCE IS PRESERVED IN ITS ORIGINAL STATE. Where loss or damage to Shore Gold property, evidence will not be disturbed until permission has been received from the Insurance Company adjuster and any government agencies involved.
8.7.2	**SERIOUS INJURY OR FATALITY INVESTIGATIONS**	Following an incident where a fatality or a serious injury has occurred, government agency representatives will likely decide to carry out an investigation into either the extent or cause of the injury/fatality. After presenting their credentials, the representatives are to be afforded full co-operation in the performance of their duties. Work at the scene of the injury/fatality may not be resumed until permission has been obtained from the Corner's Office, the RCMP and any provincial government agency involved in the investigation. Resumption of work may be permitted on a restricted basis to facilitate rescue operations.
8.7.3	**INSURANCE AND GOVERNMENT INVESTIGATIONS**	Insurance companies and Government agencies may wish to conduct investigations of their own into an incident. Once they have shown their credentials, either the designated contact for the location or his alternate must accompany them. Regulatory agencies may wish to issue orders before allowing resumption of business at the Shore Gold site following an emergency.
8.7.4	**EMERGENCY RESPONSE REVIEW**	Following any response to an emergency event, the Site Crisis Management Team will ensure the response is reviewed and recommendations implemented.

SECTION 9 – EMERGENCY PREPAREDNESS

9.1 ORGANIZATION	
	The Assistant Project Manager, along with the Site Crisis Management Team (SCMT), will develop and periodically review emergency preparedness and responses. Other duties are assigned according to the list found in Section 6. During an emergency, the membership of the SCMT will be dispersed to their various duties as assigned in Section 6 – Duties and Responsibilities.

9.2 FUNCTION	
	The Shore Gold site Assistant Project Manager and other members of the SCMT serve as a "planning body" to provide direction to and ownership of the Shore Gold Emergency Response Plan. The Assistant Project Manager will be responsible for ensuring the ERP is up to date. The SCMT will publish information on the ERP, as necessary, to ERT/MRT members, Shore Gold corporate office, appropriate Shore Gold site personnel and regulatory agencies. The SCMT will also: ↓ Conduct training on the operation of the Emergency Response Plan for personnel. ↓ Plan and execute exercises to validate the Emergency Response Plan and familiarize personnel with its provisions. ↓ Review applicable exercises and incident reports.

9.3 OPERATION	
	↓ The Emergency Response Plan will be reviewed and updated on an ongoing basis, and re-issued every three years. ↓ The SCMT will meet no less than once per year. ↓ Should an emergency occur in the time between scheduled meetings, the SCMT will meet as soon as practically possible after the event. They will examine the incident and all facets of the response to it. The expected outcomes are: ↓ A review of the actual response versus the response plan. ↓ Identification of areas to improve the response system. ↓ A plan to implement these improvements. ↓ Incident reports will be distributed to supervisors to be reviewed with employees. Incident reports are reviewed at safety meetings where applicable with more serious incidents reviewed at site wide meetings and by the SCMT. ↓ The SCMT will establish a training program for emergency response personnel. They will identify resources for this training.

SECTION 9 – EMERGENCY PREPAREDNESS

9.4 HAZARD ANALYSIS	
	Analysis refers to a qualitative assessment of the risks present in the facility. By identifying and acknowledging potential risks, we can take the appropriate steps to plan and prepare for them. The threats are divided into two broad categories; natural and man-made or technological. Man-made hazards are further divided into on site and off site.
9.4.1 NATURAL	The natural hazards that may threaten the safety of the operation and its personnel are shown on the following table.

HAZARD	POTENTIAL OF OCCURRENCE	IMPACT ON FACILITY
Lightning	MEDIUM	MEDIUM
Ice Storm	LOW	HIGH
Tornado	LOW	HIGH
Earthquake	LOW	HIGH
Forest Fire	MEDIUM	HIGH

9.4.2 MAN-MADE ON SITE	Man-made hazards that originate on site may threaten the safety of the operation, its personnel and may affect the surrounding area. Credible Accident Scenarios are detailed in Section 6 of this plan. Others that may occur on site are shown on the following table.

HAZARD	POTENTIAL OF OCCURRENCE	IMPACT ON OPERATION
Chemical Vapour Release	MEDIUM	LOW
Chemical Liquid Release Hydrocarbons	MEDIUM	MEDIUM
Structural Collapse	LOW	HIGH
Fire	LOW	HIGH
Radiation Release (Sorting equipment)	LOW	LOW
Explosion	LOW	HIGH
Transportation Accident On Site	LOW	MEDIUM
Bomb Threat	LOW	LOW
Workplace Violence	LOW	LOW

9.4.3 MAN-MADE OFF SITE	Man made hazards that originate off site may threaten the safety of the facility and its personnel.

HAZARD	POTENTIAL OF OCCURRENCE	IMPACT ON OPERATION
Access Impairment	MEDIUM	MEDIUM
Forest Fire	MEDIUM	HIGH
Transportation Accident Off Site	MEDIUM	MEDIUM

SECTION 9 – EMERGENCY PREPAREDNESS

9.5	**TRAINING**	
9.5.1	**OVERVIEW**	The Site Crisis Management Team (SCMT) will identify training and resources needed to provide the necessary skills to those personnel tasked with various duties in emergency response. There is currently a system in place at the operation for maintaining training records that will cover emergency response training activities. The primary assigned for each position within the SCMT is responsible for all aspects of training for their respective section and/or support team.
9.5.2	**SPECIFIC**	All employees not directly involved in response operations will receive training on the basic elements of the facility Emergency Response Plan as it applies to these employees. This will include what to do if they encounter a medial emergency, fire, underground emergency or an environmental emergency. This training will be held on an annual basis at the Crew Safety Meetings. All training will be documented on the Safety Meeting Planning form. The ERT members will be given initial training to certify them in the following areas: fire fighting, emergency medical response, spill response and underground mine rescue. Training will be specific to products, feed materials, processes and response equipment found at the operation. All training will be documented on the Employee Training Records form. Copies of any certificates will be placed on the employees training file located in the site Safety Office. The ERT members will participate in monthly training sessions to ensure the skills they have learned are practiced on a regular basis. All training will be documented on the Employee Training Record form.
9.5.3	**CONTRACTORS/ VISITORS**	All visitors at the Shore Gold site are escorted while on site. Short-term contractors receive orientation with appropriate ERP training, but not to the same level as a Shore Gold employee. Long-term contractors will receive similar orientation as Shore Gold employees.
9.5.4	**OFF-SITE RESOURCES**	Joint training with off site resources will include periodic tours, review of the Emergency Response Plan, participation in training activities and joint drills. Basic information about the facility layout and methods of conducting response operations will be shared with off site resources deemed applicable to this Emergency Response Plan.

SECTION 9 – EMERGENCY PREPAREDNESS

9.6	**TESTING / EXERCISING**	
9.6.1	**OVERVIEW**	Exercises are intended to accomplish a number of purposes. ↓ Validate the Emergency Response Plan. ↓ Increase familiarity with the Emergency Response Plan ↓ Increase confidence in the Emergency Response Plan. ↓ Maintain awareness of the Emergency Response Plan within the general site population. A program of testing the Emergency Response Plan has been established in the form of various types of exercises and an annual audit initiated by the SCMT. Each exercise will be evaluated and documented for maximum value. Exercise will be carried out on a regular basis according to the schedule shown below.
9.6.2	**TABLE TOP EXERCISES**	Table Top exercises are round table discussions of a potential emergency situation. They are developed to practice elements of the Emergency Response Plan and structured to meet the specific objectives identified. Table Top exercises will be conducted a minimum of once per year for each operating shift at the operation.
9.6.3	**DRILLS**	Drills are hands-on activities that test a certain element of the emergency response system, such as fire evacuation and census. Drills are based on a realistic scenario that could impact the Shore Gold site. It will involve activating personnel to handle the described emergency. Personnel will be required to respond to an evolving emergency event run on real time. Stimuli for the events of the exercise will be scripted and simulators will provide the inputs to the organization via telephone and/or radio. Frequency of drills will increase proficiency. A drill for personnel will be conducted once per year. These drills may be coordinated with a full simulation exercise.
9.6.4	**SIMULATIONS**	Full simulations test the complete emergency response organization. An actual incident is staged and the complete organization is mobilized to deal with it. External resources may be invited to participate in the exercise simulation. The Shore Gold site will conduct simulation exercises to test specific elements of the Emergency Response Plan once per year. A full simulation involving off-site contacts will be held on a three year cycle.

FORM 1A

SECTION 10 – Check Lists

TIME AND EVENT LOG

Name:_____ Date: _____ Page No. _____

#	TIME	EVENT/ISSUE/CONTACT	ACTION TAKEN

FORM 1B

SECTION 10 – Check Lists

BOMB THREAT/ANONYMOUS THREATENING PHONE CALL RECORD

Do Not Interrupt – Answer "Yes" or "No"	**Be Calm And Courteous – Listen Carefully**

Time: _____ **Date:** _____

Message: _____

_____

Is the caller: Male ☐ Female ☐ Middle Aged ☐ Young ☐ Old ☐

Does caller have an accent: Yes ☐ No ☐ What kind of accent: _____

Did he/she mispronounce their words: Yes ☐ No ☐

Was caller:	Laughing	Yes ☐	No ☐
	Drunk	Yes ☐	No ☐
	Angry	Yes ☐	No ☐
	Excited	Yes ☐	No ☐
	Loud or Soft Spoken	Yes ☐	No ☐

Did you hear any background noises – traffic, machinery, music, talking:

_____

Other comments: _____

_____

Ask the following questions, if possible, AFTER the caller gives the message:

1. Where is the bomb located?
2. What time will the bomb explode?
3. When was the bomb placed?
4. Why was the bomb placed?
5. What type of bomb?
6. Who are you?
7. What organization do you represent?

Immediately notify Security. Security will in turn notify the Assistant Project Manager who will activate Emergency Response Plan.

Notified site senior management at _____ (Time/Date) _____

Notified RCMP at _____ (Time/Date) _____

Name of person handling call (Please Print) _____

SECTION 11 – ADMINISTRATION

11.1 AUTHORITY	
	Shore Gold will manage all resources and personnel to minimize injury to personnel, damage or destruction of property and promote rapid return to normal operations.

11.2 LEGISLATION	
	Any legislation and regulations affecting the Shore Gold site will be referred to and kept in a location that is handy for key personnel. Some examples of such legislation are: ↓ Canada Environmental Protection Act. ↓ Saskatchewan Environmental Protection Act. ↓ Saskatchewan Environment Operating Approval. ↓ Transportation of Dangerous Goods Act and Regulations. ↓ Saskatchewan Labour Standards ↓ Saskatchewan Occupational Health and Safety Act, 1993 ↓ Saskatchewan Occupational Health and Safety Regulations, 1996 ↓ Saskatchewan Mines Regulations, 2003

11.3 POLICY	
	Shore Gold will develop, maintain and test emergency response plans to prevent and mitigate the impacts on employees, the public and the environment. The development of such plans is to be consistent with the following three priorities: protection of human life, protection of the environment and protection of property.

11.4 GLOSSARY OF TERMS	
	Definitions are necessary to maintain consistency of terms used in emergency planning, response and post-incident recovery.
TERM	**DEFINITION**
SCMT:	Site Crisis Management Team
CCCP	Corporate Crisis Communication Plan
EMERGENCY RESPONSE TEAM:	First response team for handling fire, process emergencies and spills.
Emergency Medical Personnel	Includes Emergency Medical Technicians and First Responders.

SECTION 11 – ADMINISTRATION

11.5 REVIEW AND UPDATING	
REVIEW TIMING	The Emergency Response Plan will be reviewed and updated on an ongoing basis and re-issued every 3 years. Select members of the SCMT will carry out the review. Items that will be checked are: ↓ Changes in resources ↓ Changes in hazards ↓ Training ↓ Exercises ↓ Actual Incidents Any changes identified in the review will be incorporated into the manual and the training and exercise program. Select members of the SCMT will make the changes.

11.6 DOCUMENT CONTROL	
CONTROLLED COPIES	There are 15 copies of this manual as per the distribution list in section 11.7. All efforts will be made to keep these manuals up to date and current. Additional copies are considered Uncontrolled Documents, and as such, are not considered to be accurate.

11.7 DISTRIBUTION	
	Copies of the Emergency Response Plan are distributed according to the following distribution list. Each copy is numbered and the person responsible for it is shown beside its location. Overall responsibility for the manuals and their distribution rests with the Senior Safety Coordinator.

SECTION 11 – ADMINISTRATION

11.7.1 DISTRIBUTION LIST

Manual #	Responsible Position	Location	Format
ERP 1	Project Manager	Corp Office	Paper
ERP 2	Assistant Project Managers	Site Office	Paper
ERP 3	Mill Foreman	Site Office	Paper
ERP 4	Environment Manager	Corp Office	Paper
ERP 5	Environment Coordinators	Site Office	Paper
ERP 7	Site Services Supervisors	Site Office	Paper
ERP 8	Security General Foreman	Site Office	Paper
ERP 9	Administrative Assistants	Site Office	Paper
ERP 10	Safety Coordinators	Site Office	Paper
ERP 11	Security – Main Gate	Gate House	Paper
ERP 12	ERT Captain	Site Office	Paper
ERP 13	Emergency Medical Personnel	Site Office	Paper
ERP 14	Senior Project Geologists	Site Office	Paper
ERP 15	Human Resources	Corp Office	Paper

APPENDIX 7-B

Hazardous Materials Management Plan

1.1.1 Hazardous Materials Management Plan

1.1.1.1 Introduction

This Management Plan outlines the hazardous substances and waste dangerous goods (HSWDG) that are expected to be handled on Site. It outlines proper storage and disposal locations, waste products generated, and a general description of fuel storage areas. This plan also contains an updated spill contingency plan, outlining detailed information on the risk and hazard analysis, safety considerations, initial spill response, and documentation and reporting protocol. The step by step procedures for initial spill response and reporting requirements were developed during exploration for employees and contractors to reference in the event of a spill. This plan was developed to educate employees/contractors to promote spill prevention and minimize spill occurrences. As the project develops and the site layout and storage facilities are finalized and constructed, this plan will be updated to reflect the current conditions and to address the current risk factors associated with the project.

As part of the Shore Gold staff and contractor orientation, all employees will be required to review the *HSWDG Storage and Handling Work Instruction* which will describe in detail how to handle, transport and dispose of each HSWDG material. This work instruction will also be available to all employees and will be placed in strategic areas such as at storage locations to act as a reference for employees. This will ensure that all HSWDG will be properly handled while on Site and will also be properly disposed of. Daily inspections of the Site will also be completed to ensure the management plan is being adhered to and to enforce disciplinary recourse for acts of non-compliance. All HSWDG storage, handling and disposal sites will be part of these inspections.

The HSWDG plan incorporates the principles of reduce, reuse, recycle, and recover. Decreasing the volume of waste generated on Site will increase cost efficiency and reduce the project's environmental impacts.

As the project develops, revisions to the *HSWDG Management Plan* will be ongoing to ensure any different or new wastes and materials are included and to indicate any updates to storage and disposal facilities. The plan will be reviewed and updated annually or when the need for revisions is warranted.

1.1.1.2 Transport

All employees and contractors must know which substances they handle are classified as HSWDG. Hazardous wastes are substances which can cause illness, disease, or death to unprotected people. The dangers of hazardous materials can come from explosion, fire, skin contact, inhalation, and consumption. A list of all the HSWDG shipped to the Site will be kept with the Shore safety department, along with the appropriate WHMIS (Workplace Hazardous Materials Information System) information associated with each product. The location where it is kept will be well known and available for employees to view.

It is important to be aware of the characteristics of the HSWDG being handled and the associated hazards of the HSWDG. Workers can protect themselves from hazardous materials by reviewing the Material Safety Data Sheets (MSDS) to learn about the precautions and proper handling techniques. A MSDS binder for all products on Site will be located in accessible and known locations and will also be available for all employees. An electronic MSDS binder will also be kept in the administration building.

The appropriate PPE must be worn at all times while handling the hazardous substance. All employees and contractors working on Site will complete the Workplace Hazardous Materials Information System (WHMIS) course through the Saskatchewan Construction Safety Association (SCSA) WHMIS Training Program. WHMIS provides workers with training and the safe handling of hazardous materials to ensure their own safety and the safe of others in the workplace. It is everyone's responsibility on Site to ensure that hazardous materials are properly labeled and handled in a safe manner.

1.1.1.3 Hazardous Materials Storage

All hazardous substances and waste will be stored in accordance with *The Hazardous Substances and Waste Dangerous Goods Regulations* and permit conditions if applicable. This is to prevent waste material from entering the environment in the occurrence of a spill. Secondary containment will be used where necessary and will be impermeable (leak tight) and constructed of a material compatible with the waste being stored. Frequent inspections will be conducted to ensure the secondary containment is free of accumulations of rain, snow, and debris. All HSWDG containers and storage areas will be properly labeled to identify the hazardous substances.

Work areas such as the processing plant, drilling rigs, and workshops may temporarily store HSWDG waste materials in containers with an appropriate means of secondary containment. Once the waste storage containers are full they will be transferred and disposed in appropriate containers in a centralized HSWDG Storage Facility or Facilities. All aspects of the Management Plan will be in compliance with *The Hazardous Substances and Waste Dangerous Goods Regulations*.

There will be numerous HSWDG Storage Facilities in many locations around the Site. Each Facility will be marked with signage, well known, introduced during orientation and will also be part of regular inspections. There will be storage facilities dedicated to virgin materials and other separate facilities for contaminated material awaiting disposal off site. Landfills in the area (Nipawin, Prince Albert, etc.) will be utilized for any materials which are not recyclable or suitable for the incinerator (used oil, contaminated soil, hydrocarbon contaminated absorbents, etc).

Detailed work instructions will be developed and distributed to employees. These will provide employees with guidance on the proper handling, storage and disposal procedures and locations for:

- Waste oil and hydrocarbons
- Empty 45 gallon drums
- Empty 5 gallon pails
- Contaminated soils
- Used Batteries
- Hydrocarbon contaminated materials (rags, cardboard, booms, etc)
- Oil filters
- Used antifreeze
- Paint and associated containers
- Fluorescent lights
- Virgin HSWDG Materials
- Any other material which is a HSWDG and is on site

It is expected that a fuel tank farm will be established near the administration buildings to provide the necessary fuel needs. All fuel storage facilities will be installed, maintained, and decommissioned according to the *Hazardous Substances and Waste Dangerous Goods Regulations.* All tanks will be double-walled and will be inspected by a certified contractor prior to use. A visual inspection will also be conducted on a daily basis to check the tanks for deficiencies and leaks. Regular reconciliation of delivered and used volumes of fuel will also be completed.

When necessary, decommissioning of petroleum storage facilities will be performed by qualified personnel, pursuant to the *Hazardous Substances and Waste Dangerous Goods Regulations*. An application to decommission petroleum storage facilities will be submitted to MOE prior to commencing decommissioning activities. A closure report will be submitted to MOE following decommissioning which will outline any required remedial activities.

1.1.1.4 Record Keeping

Up to date records will be kept of the locations and materials kept in each HSWDG storage facility. Detailed records of the contents of each facility will also be kept at each facility where the contents regularly change (i.e. HSWDG contaminated and used hydrocarbon storage facility).

Documentation of incidents is also extremely important and will be initiated early in the response and maintained throughout the event. The first responder to a spill will collect the following information to forward on the Environment Department:

- Date and time of the release
- Location point of the release

- Volume and type of substance
- Cause of the release
- Initial response activities

All spills must be immediately reported to the designated department, regardless of substance or volume, who will determine if the spill is reportable by comparing the quantity spilled with reportable quantities presented in the provincial *Environmental Spill Control Regulations.*

If the spill is reportable then the MOE Spill Control Centre (1-800-667-7525) will be immediately notified of the spill, followed by a verbally notification to the MOE Project Officer, or their designate. Since the MOE Spill Control Centre will also notify the MOE Project Officer, leaving a voice message at the MOE office is acceptable. The following information will be provided:

- Location and time of spill;
- Type and quantity of material spilled;
- A description of the location of the spill and immediate surrounding area
- Details of action taken and proposed to be taken at the spill-site to meet the requirements to prevent further discharge, contain the spill, minimize the effects and restore the area affected
- Details of investigation into the spill.

Within 7 days of verbal notification, a written report including cover letter will be submitted to the MOE Project Officer. The report should include the following information:

- Location and time of spill;
- Type and quantity of material spilled;
- A description of the spill site area, including proximity to potential receptors;
- Names of all personnel notified of the spill;
- The cause and effects of the spill;
- Remedial action taken;
- Further action being considered; and
- Measures being considered to reduce the potential for recurrence.

A copy of the *Written Spill Report Form* to the government and all other correspondence concerning the incident will be kept as a record.

1.1.1.5 Inspection Program

Daily inspections will be conducted by the Environment Department throughout the Site. Inspections will be conducted to check for the neatness of work areas, condition of pipes,

hoses, connectors on equipment and facilities, surficial staining of soil, leaking containers/ equipment, and appropriate storage containers. Any deficiencies found during the daily inspection will be promptly addressed. Detailed records of each inspection will be kept and any deficiencies will be logged as well. Any spills of HSWDG will result in an environmental incident report and investigation being completed. A plan will be put into place with the responsible persons to ensure the deficiency is not repeated.

Work areas that contain the potential risk for a release of a hazardous substance will be identified and precautionary protocols will be in place and well known. Fuel storage and fueling stations will be identified as a risk for substance release. Spill kits will be placed at all fueling stations and any other areas where there is a significant risk of substance release such as the HSWDG storage and disposal areas. Placing materials/substances in the proper locations within the designated storage facilities and maintaining good housekeeping will minimize the risk of spills.

1.1.1.6 Spill Contingency Plan

Shore is committed to promoting spill prevention and enforcing spill response procedures through employee training and awareness. This disciplined approach to spill response was developed during exploration to enforce safety, minimize property damage, and minimize negative impacts to the environment. This approach will continue and will be built upon during construction and operations.

Hazardous material spills present a number of common issues that can be managed to avoid impact to people, property, and/or the environment. It is important to know the characteristics of the spilled product and identify physical hazards to safely assess the site and develop a response strategy that doesn't compromise safety.

Personnel will be aware of the properties of the products that they handle and have access to *Material Safety Data Sheets* (MSDS). MSDS binders containing all the products used on Site will be located in easily accessible areas such as the main office and warehouse. The proper *Personnel Protective Equipment* (PPE) will be worn at all times. The goal of having PPE is to prevent exposure to toxicity entering the body by inhalation, ingestion, and skin absorption.

In some situations, signs and/ or barricades may need to be used to ensure the safety of the public and keep non-essential personnel out of the hazard area.

Hydrocarbons such as gasoline and diesel fuel are substances with a high spill potential due to frequency of transportation and use and abundant storage on Site. Hydrocarbon spills present the following hazards:

- The vapors from flammable liquids will ignite in the presence of sufficient oxygen and an ignition source.
- Flammable vapors from a spill can migrate off-site, creating a hazard area that extends beyond the obvious spill perimeter.

- Uncontrolled ignition of vapors is a concern and can lead to explosions when confined spaces are involved and/or a flash back to the vapor source.
- During the normal weathering process of spilled hydrocarbon, light ends will be released at varying rates. Fire and explosion hazards are most prevalent during the early stages of a spill, but may exist during the entire clean up period.
- Direct contact with hydrocarbons may cause severe eye and skin irritation that can be accelerated if the person has a pre-existing medical condition.

Hydrocarbon spills can have an adverse affect on the environment. Spills that migrate into the surface water and have the potential to contaminate the water supplies, damage shorelines, and pose undesirable affect on the aquatic organisms and wildlife. Land based spills can penetrate into the soils and effect soil structure, vegetation, and have the potential of contaminating groundwater resources and water wells.

A detailed and site specific Spill Contingency Plan will be developed and reviewed and will be designed based on the current layout of the site. In general, all spills that are discovered will be immediately reported to Shore's Environment Department.

There are three initial steps which will be completed when responding to a spill.

Identification – Find out the substance that was released and assess any potential hazards associated with that substance. Is the substance a hazardous waste? What PPE is required? The spilled material should be correctly identified prior to handling the substance.

Containment – Once you have identified all potential hazards and are equipped with the proper PPE, stop the source of leakage. For example, close the valve or plug the leaking hose. The substance must be isolated and contained to keep it from spreading. Materials from the spill kits should be utilized to help contain the substance.

Recovery/Cleanup/Disposal – If possible the substance should be collected from the ground surface as soon as possible. A sorbent pad can soak up the substance from the ground for small spills. The Environment Department will develop a plan of action to properly clean-up spill areas and disposal of the released substances.

It is important to recognize that not all spills are the same and spill response plans and clean-up activities are situation specific. Here are some general rules that apply to almost all containment and recovery operations for land-based spills:

- Minimize the use of heavy equipment where possible and avoid excessive surface disturbance.
- Remove as much free liquid from the surface as quickly as possible.
- Prevent surface water from entering the spill site.
- Salvage topsoil.
- Never bury hydrocarbon or contaminated soil.

- Avoid unnecessary damage to vegetation.
- Consider all options to remove contaminants and be prepared for changes to occur.
- A thorough initial cleanup will reduce reclamation time and rehabilitation costs.

There are various common techniques used for containment and recovery of spills. Spill barriers such as dams, dykes, and berms can be used to block existing drainage systems and redirect spilled product. In situations where the substance was released onto water, trenches and bell holes can be dug and used in conjunction with a skimmer to collect spilled products off the water surface. Sorbent pads and booms are ideal for small spills and can be utilized to absorb the spilled product. Vacuum trucks can be used to remove spilled materials from soil and water.

Spill kits will be placed around all fueling stations and other work areas with the potential for a substance release. The spill kits will contain sorbent pads, sorbent socks, plastic sheeting, safety glasses, nitrile gloves, etc. The sorbent pads can be used to absorb the released substance from the ground surface and the sorbent booms can be used to contain the substance. Nitrile gloves and safety glasses should be worn when handling any released substance.

In addition to the Spill Contingency Plan, there will also be an Environmental Emergency aspect to the Emergency Response Plan which will indicate, in detail, which actions to perform in what order when an environmental emergency takes place. This plan will also describe which person(s) is (are) responsible for what action upon finding the Environmental Emergency.

APPENDIX 7-C

Weed Management Plan

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1.0 INTRODUCTION

The Shore Gold Fort a La Corne (FALC) Diamond Project is located approximately 30 km south of Smeaton, Saskatchewan in the FALC Forest. As described in the FALC Draft Integrated Forest Land Use Plan (SMOE 2005), the FALC Forest in 'an island forest, surrounded by agricultural lands with a long history of activities such as timber harvesting, tourism, hunting, livestock grazing, and some haying'. As a result of the activities in the FALC forest, weed species are present, although native vegetation is predominant. Stands of jack pine make up 98% of the forest (SOME 2005).

1.1 PURPOSE

The purpose of the Weed Management Plan is to:

- Minimize the introduction and establishment of undesirable new weed species
- Establish a monitoring program for weed species that are present or become established
- Develop and implement strategies to quickly remove or prevent the spread of weed species that become established
- Prioritize species requiring control and customize control techniques for different species as required
- Ensure continuous and ongoing control of weed species, including during reclamation activities in order to promote natural revegetation

2.0 DESCRIPTION OF NOXIOUS WEEDS

2.1 NOXIOUS WEED LIST

The Saskatchewan Conservation Data Centre provides a 'Saskatchewan Noxious Species List". This list will be used to identify what are considered noxious weeds requiring management under this plan. An updated list will be used whenever available. The most recent list was released in February, 2012 and is as follows:

- *Acroptilon repens*; Russian Knapweed;
- *Arctium minus;* Common Burdock;
- *Artemisia absinthium*; Absinthe;
- *Berteroa incana*; Hoary-alyssum;
- *Bromus japonicas*; Japanese Chess;
- *Bromus tectorum*; Downy Chess;
- *Cardaria draba ssp. chalapensis*; Chalapa Hoary-cress;
- *Cardaria pubescens*; Long-stalk Hoary-cress;
- *Carduus nutans*; Nodding Thistle;

- *Cirsium arvense*; Canada Thistle;
- *Cirsium vulgare*; Bull Thistle;
- *Convolvulus arvensis*; Field Bindweed;
- *Crepis tectorum*; Annual Hawksbeard;
- *Erodium cicutarium*; Stork's-bill;
- *Euphorbia cyparissias*; Cypress Spurge;
- *Euphorbia esula*; Leafy Spurge;
- *Galium aparine*; Cleavers;
- *Gypsophila paniculata*; Baby's Breath;
- *Hesperis matronalis*; Dame's Rocket;
- *Hyoscyamus niger*; Black Henbane;
- *Kochia scoparia*; Summer-cypress;
- *Lactuca serriola*; Prickly Lettuce;
- *Leucanthemum vulgare*; Ox-eye Daisy;
- *Linaria vulgaris*; Yellow Toad-flax;
- *Lolium persicum*; Persian Darnel;
- *Lythrum salicaria*; Purple Loosestrife;
- *Malva rotundifolia*; Running Cheeseweed;
- *Matricaria perforate*; Scentless Chamomile;
- *Pastinaca sativa*; Parsnip;
- *Rhamnus cathartica*; Buckthorn;
- *Silene latifolia ssp. alba*; White Campion;
- *Silene noctiflora*; Night-flowering Catchfly;
- *Silene vulgaris*; Bladder Campion;
- *Sonchus asper*; Prickly Sow-thistle;
- *Sonchus oleraceus*; Annual Sow-thistle; and
- *Tanacetum vulgare*; Tansy.

Source: Saskatchewan Conservation Data Centre. February 2012. Saskatchewan Noxious Species List. Regina, Saskatchewan.

3.0 WEED MANAGEMENT

3.1 POTENTIAL IMPACTS

As the mine is developed, areas will be disturbed and exposed, which will create potential opportunities for establishment of new weed species or spreading of existing ones. Some areas

will remain disturbed for long periods of time (years) which increases the likelihood that weed species can become established. Increased traffic and equipment coming to the project site from outside the forest also has the potential to transport weed seeds.

3.2 CONTROL MEASURES

3.2.1 Prevention

The preferred method of weed management is to prevent the establishment and spread of weed species. This will be completed in a number of ways. All vehicles and moving equipment will be expected to be clean and free from outside seed sources when brought onto the project site. Contractors and employees will be made aware that all vehicles and equipment must be clean of outside soil and potential seed carrying material before they enter the project site. Part of the site orientation will include awareness of the importance of maintaining clean equipment, and minimizing transportation of weed seeds.

3.2.2 Removal

The second method of weed management will be the identification and removal of weed species before they become an established population. Regular inspections of all impacted sites and areas of activity will be completed by on site environmental staff. Environmental staff will be trained in the identification of weed species and will look for, and document any areas where weed species are present. These areas will be recorded and a management plan put into place as outlined below.

The physical removal of weed species will be performed by Shore Gold staff using physical, mechanical or chemical means as required and approved. The removal method will depend on the level of infestation and type of weed. Some specific control strategies will include physical removal and incineration, mowing or chemical application. In the case of chemical application, the management plan will first be approved by the Saskatchewan Ministry of Environment (SMOE) because the FALC is a Provincial Forest.

3.2.3 Monitoring

Mapping of the weed species will be ongoing to provide guidance on where monitoring should be concentrated in subsequent years, as well as a history of the successful removal or the potential spread of weeds. Mapping will include species, location, density, and area. This mapping will be critical in assessing the success of the weed management program from one year to the next.

During all aspects of reclamation, including planning and monitoring, weed management will be considered and control measures implemented wherever weed species become established. Progressive reclamation will also ensure that disturbed sites and piles are revegetated with native species as soon as possible, minimizing the amount of time that the areas are susceptible to colonization by weed species.

Access roads (within the FALC forest) can be considered as part of the Project Site in terms of the control of weed species if access roads are determined to be a significant source of weed seeds. All of the inspection and control measures of the Weed Management Plan would then be applied to the access roads. This can be an important part of the overall strategy, as the access roads travel through a significant portion of the forest and have the potential to spread weed seeds in the area for the length of the road.

If a species of weed becomes an established population, then a specific management plan will be created and implemented in order to remove the population, or if that is not possible, minimize any further spread and impacts of the population.

3.3 RESPONSIBLE STAFF

3.3.1 Environmental Manager

- Ensure all aspects of the Weed Management Plan are implemented; and
- Ensure reporting is complete to fulfill requirements.

3.3.2 Site Environmental Team

- Complete the work at the project site, identify weed infestations;
- Assess and improve the Management Plan on an ongoing basis; and
- Keep records and document the data to ensure it is available to fulfill the reporting requirements.

3.3.3 Site Manager

- Work with the Environmental Team to ensure the Weed Management Plan is implemented and accepted;
- Include considerations of this plan when planning new or changes to operations; and
- Ensure the site orientation includes aspects of the weed management plan where applicable.

3.4 RECORDS AND REVIEWS

A summary of the Weed Management Program will be included in the Annual Environmental Report of the Project. This will include:

- A summary of any infestations as well as how they were managed;
- An assessment of the success (or failure) of the management strategy;
- A discussion of how to improve weed control in subsequent years;
- An assessment of the monitoring program and any changes that may be required in order to ensure weeds are quickly detected and removed; and

- Mapping of detected weed species which will be completed whenever a population becomes established.

Mapping will be a key part of the report and will also include a year over comparison to ensure the Weed Management Program is effective and constantly improving. An annual review of the weed species and populations present will also be completed at this time and specific species management plans will be created if shown through the review to be required (i.e. if year over year comparison shows that establishment and population size are increasing). One mapping results are available, then targets, objectives and measures can be established and put into place in order to focus the management program and ensure progress is being made. For example, area covered by weed X to be reduced by XX% within 24 months would be an example of a measureable target.

The Weed Management Plan will also be reviewed and updated every year to reflect the current status of weed populations, as well as incorporate all improvements and updates made to the plan. This update will be after the Annual Report is complete in order to incorporate all the data presented in the Annual Report.

4.0 SUMMARY

This Weed Management Plan will be the basis for the Weed Management Program at the Star-Orion South Diamond Project and will be continuously updated using the information, successes and challenges observed during the project. The key aspects to the Weed Management Plan are:

- Prevention of weed establishment and spreading;
- Removal of problem weeds if they do become established;
- Monitoring and continuous improvement of the program in terms of the presence of weed species; and
- Data collection, management and reporting.

APPENDIX 7-D

Fire Plan- 2014

Shore Gold Inc.

Fort a la Corne - Star Diamond Project

Fire Plan 2014

Revised July 2014

FALC Site - Fire Plan

Location

The Shore Gold - Fort a la Corne -Star Diamond Project (Shore Gold Exploration Site) is located approximately 100 Kms east of Prince Albert, SK and approximate 27 Kms south of Highway 55 from Shipman. The Fort a la Corne Star Diamond Project is located within the confines of the Fort a la Corne Forest. Access to the Shore Gold Exploration Site is via grid road directly south of the village of Shipman to the northern entrance of the Fort a la Corne Forest; however Shipman trail has been impassable in the spring recently. The Site can also be accessed from the East from Highway #6 at a point approximately 27 Km's west along the Division Road or from the west approximately 30 Km's via Garden River Road; however Division Road West has not been passable for several years due to flooding. An Access Map is attached as Appendix "A" to this Fire Plan for Reference but as noted above, Division East is the only reliable access to the site.

Operations and Personnel

As of January 2014 the Shore Gold Exploration Project (Site) has relinquished it's on site personnel and has been temporarily closed. However, frequent site visits take place on a weekly basis over the course of the year by Shore Gold management. In the case of a building or forest fire, during site checks by current management, the fire plan below will be the course of action taken. In addition, video feed is available at the FALC JV core site and is maintained by Prince Albert Alarm Systems. Instructions to contact management if smoke is observed on the camera have been discussed. Following recognition of smoke in the area the Primary Contact List will be notified immediately. It is noteworthy that previously employed members of the Shore Gold team are still available for site checks if requested. Their contact information is also available within Appendix B (Secondary Contact).

Fire Plan

1) When a fire has been identified in the Shore Gold Exploration Site area and initial efforts to extinguish the fire have proven futile, information about the fire and its location will be communicated to off-site personnel by the quickest and most efficient means available (radio or phone). Following notification of the fire a prompt call to the Forest Fire Center in Prince Albert will be made to alert crews of the location and size of the fire.

2) Once the fire's location and type has been assessed the offsite Shore Gold Primary Contact, as identified on the Emergency Contact List, will contact the appropriate Fire Response Center and relay all pertinent information as required.

Structural Fires on Site:
Contact the **Smeaton Fire Dept**. via the **911** Call format.

Forest Fires on Site:
Contact the **Forest Fire Centre, Prince Albert – 1-800-667-9660**

3) The Shore Gold Primary contact will then advise the Project Manager or designate of the situation. The Shore Gold Primary Contact will take control of the situation and activate all resources available.

Site Evacuation Plan

1) In the event that there is a Fire Threat to the Shore Gold Exploration Site the Forest Fire Center, Prince Albert will notify The Primary Contact, as indicated in Appendix "B", the "Emergency Contact List". The Fire Control Center will advise that there is a Forest Fire threat to the Shore Gold Exploration site and will advise of the fire's location, speed, and direction of travel. The Forest Fire Control may recommend that the affected area be evacuated.
2) In the case of a general evacuation, the Primary Site Contact will advise all on Personnel on site and or contractors that the Site is to be evacuated. All persons will be advised of the safest evacuation route to be followed. East Division Road is currently the only reliable evacuation route due to flooding A Map of Evacuation routes from the Shore Gold Exploration site is attached as APPENDIX "A."
3) If there is a Forest Fire threatening the Shore Gold Exploration area the Evacuation Routes will be via Division Road East to Hwy# 6 or if Dision Road East is impassable, then Division Road West to the Shipman Trail and North to Hwy # 55. The Evacuation routes will be dependent on Fire Location and its direction of Travel. The Safest route of evacuation will be followed.

Fire Center Control Contact

Emergency Fire Watch	**1-800-667-9660**
Forest Protection Officer	**1-306-953-3422**
	Cell: 1-306-230-5110
Fire Base Supervisor	**1-306-953-3422**

Shore Gold Contacts:

Note that no personnel are stationed on site at this time

See attached APPENDIX "C "

Shore Gold - Main Site Location

GPS East 514626

North 5897325

Note: There is room to land two Helicopters on the Helicopter Pad at this location.

Shore Gold - Camp Location

GPS East 515993

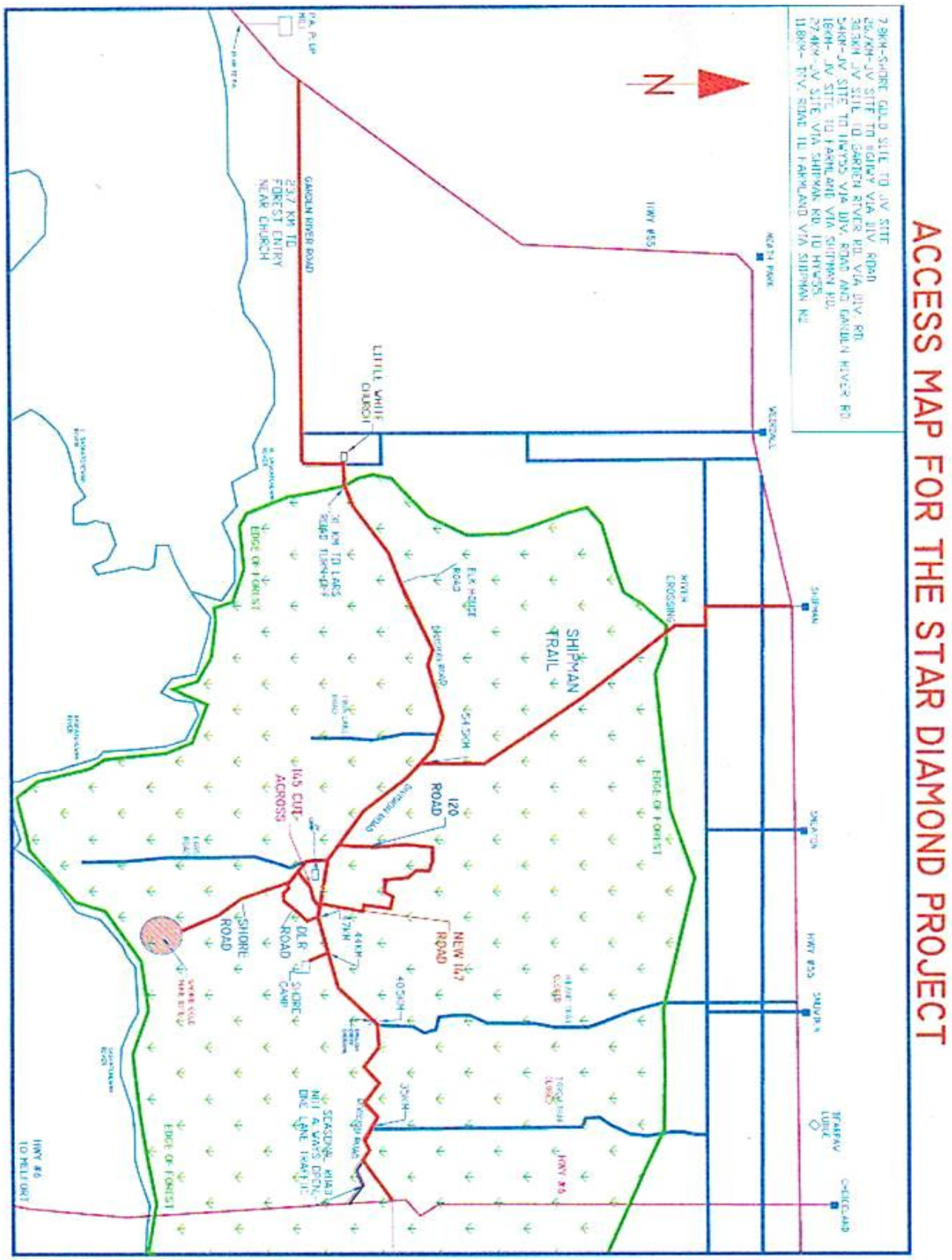
North 5902917

Note: This location is Helicopter accessible.

Available Equipment

a) **938 Wheeled Front end Loader 1**
b) **John Deer Back Hoe 1**
c) **Zoom Booms (Motorized) 1**

Appendix "A"


ACCESS MAP FOR THE STAR DIAMOND PROJECT
N
HIWY #55
GARDEN RIVER ROAD
237 KM TO FOREST ENTRY NEAR CHURCH
LITTLE WHITE CHURCH
EDGE OF FOREST
SHIPMAN TRAIL
ELM RIDGE ROAD
120 ROAD
NEW 147 ROAD
SHORE ROAD
DLR ROAD
HIWY #6 TO MELFORT
SEASONAL ROAD
EDGE OF FOREST

Shore Gold Inc.

July 2014

EMERGENCY CONTACT LIST

Medical Emergency Contacts

AMBULANCE/	**911**	**All Medical emergencies will utilize 911 and must contact Shore On Site Contacts who will arrange for the Mobile Treatment Vehicle.**

Fire Emergency Contacts

Smeaton Fire Dept. 1-306-426-2044	**911**	**All Fire Emergencies will utilize 911 or 1-306-426-2044 request Smeaton Fire Dept. and must contact Shore On Site Contacts**
FOREST FIRE CENTRE, P.A.	**1-800-667-9660**	**All Forest Fire Emergencies will utilize 1-800-667-9660 and must contact Shore On Site Contacts**

Environmental Emergency Contacts

SASK. SPILL RESPONSE CENTRE	**1-800-667-7525**	**All Environmental Spills must be reported to Site Contacts.**

Primary Contacts

Note: all contacts are based in Saskatoon- no personnel are currently stationed on site

- Project Manager	**306-xxx-xxxx**
- Environmental Manager	**306-xxx-xxxx**
- Sr. Project Geologist & Land Manager	**306-xxx-xxxx**

APPENDIX 7-E

U of A Reclamation Research

RECLAMATION OF DISTURBED SITES

AT THE STAR-ORION DIAMOND PROJECT IN SASKATCHEWAN

PRELIMINARY GREENHOUSE RESEARCH

FINAL REPORT

Prepared by

Dr. M. Anne Naeth

Ms. Sarah Wilkinson

Department of Renewable Resources

University of Alberta

Submitted to

Mr. Ethan Richardson

Shore Gold Inc.

June 2011

1. BACKGROUND

Diamond mining is an important industry in Canada, with active mines in the Northwest Territories and northern Ontario and with potential for development in other regions including northern Saskatchewan. The Canadian diamond mining industry has the challenge to reclaim mining disturbances and the opportunity to develop innovative, cost effective and environmentally sustainable reclamation methods. Successful reclamation involves substrate development with re-establishment of soil processes and revegetation to support trajectories towards appropriate plant communities. Sites to be reclaimed vary with mine sites, but generally they include gravel roads, gravel pads, waste rock and till stockpiles and considerable amount of processed kimberlite tailings.

Shore Gold's Star-Orion South Diamond Project is located in Fort a la Corne Provincial forest, at the southern edge of the boreal forest in central Saskatchewan. The region receives more precipitation and has a longer growing season than arctic regions, where diamond mine reclamation research has mainly focused to date. Lack of soil organic matter, poor water holding capacity and low nutrients of available substrates are significant obstacles on disturbed sites in the arctic and in northern Saskatchewan. Thus the research conducted in the arctic sites can be a good starting point for reclamation of the Star-Orion South Diamond Project. The main potential end land uses for mined sites in northern Saskatchewan include forestry and native plant communities.

Processed kimberlite is a waste material from diamond mining that has potential reclamation uses. Reclamation research on processed kimberlite at various mine sites in the Canadian north has shown that amendments are required to enhance physical structure and chemistry of the tailings (Reid and Naeth 2005a, 2005b; Drozdowski, Naeth and Wilkinson 2011; Naeth and Wilkinson 2011). Without amelioration of both structural and chemical components, establishment of vegetation is extremely poor and not sustainable. Chemistry and structure of processed kimberlites differ depending on geologic parent material. Processed kimberlite properties and local availability affects selection of appropriate amendments for reclamation.

In this study, three types of processed kimberlite were investigated to determine their potential, alone and amended, as substrates for successful reclamation on disturbed sites at the Star-Orion South Diamond Project in northern Saskatchewan. This greenhouse research was designed to facilitate narrowing the list of potential amendments and plant species prior to field research on the mine site.

2. RESEARCH OBJECTIVES

The research goal is to identify effective and economical methods for using waste materials to reclaim disturbed sites at the Star-Orion South Diamond Project in Saskatchewan. Specific research objectives of this greenhouse study are as follows.

- To assess processed kimberlite materials as potential substrates for plant establishment, development and growth.
- To assess select amendments to enhance processed kimberlite properties.
- To assess whether select plant species can establish and survive on processed kimberlite.
- To determine potential uses of processed kimberlite in agriculture and forestry operations.

3. MATERIALS AND METHODS

3.1 Experimental Design and Treatments

A completely randomized design greenhouse experiment was established at the University of Alberta in June 2010. The experiment ran for 12 weeks.

Three potential reclamation substrates from the Star-Orion South Diamond Project that require reclamation were provided by Shore Gold Inc. for the greenhouse experiment. Substrates used were fine processed kimberlite from the Star deposit, fine processed kimberlite from the Orion South deposit and a mix of coarse processed kimberlites from Star and Orion South. These were common materials likely to be used for reclamation after mining.

Five soil amendments were selected to enhance physical and chemical properties of the reclamation substrates based on results of prior research in other reclamation scenarios and availability. Amendments were native sandy soil from Fort a la Corne Provincial Forest, agricultural soil from immediately north of the Fort a la Corne Forest, inorganic nitrogen phosphorus fertilizer (11-52-0 applied at 28 kg ha^{-1} nitrogen) and biosolids and yard composts from the City of Prince Albert Compost Facility. Amendments were mixed with reclamation substrates at a 50 % by volume ratio. As this is the first study to be conducted using processed kimberlite from the Star-Orion South Diamond Project, a 50:50 application rate was considered an appropriate starting point from which to assess the interaction of physical and chemical properties of the materials and determine application rates more specific to each amendment based on preliminary results.

The reclamation goal for the Star-Orion South Diamond Project is to return the site to a productive vegetation community similar to other areas within the Fort a la Corne Provincial Forest. Potential plant species for use in reclamation include native and agronomic grasses, legumes and agricultural crops or trees.

Seven plant species were selected for greenhouse research. They were four native grasses, *Agropyron trachycaulum* (Linke) Malte (slender wheat grass), *Elymus innovatus* Beal (hairy wild rye grass), *Festuca saximontana* Rydb. (rocky mountain fescue) and *Koeleria macrantha* (Ledeb.) J.A. Schultes. f. (june grass); two agronomic forages, *Hordeum vulgare* L. (barley) and *Bromus elatior* (l.) Koeler (meadow brome grass); and one tree species, *Populus tremuloides* Michx. (trembling aspen).

Grasses were obtained from Brett Young Seeds in Calmar, Alberta. Aspen seed was obtained from Shand Greenhouses in Estevan, Saskatchewan. Single species were sown per pot at a rate of 10 to 15 seeds depending on documented germination for each species. *Hordeum vulgare* and *Bromus elatior* densities were reduced to five plants per pot two to three weeks following seeding to prevent crowding and a non-treatment induced reduction in plant health.

Substrates and amendments were thoroughly mixed in the appropriate proportions prior to filling five inch diameter pots with the final treatment mix. Each combination of substrate-amendment-species was replicated five times. Controls consisted of each substrate unamended and commercial potting soil. Greenhouse temperature was set at 21 ^{o}C during the day (16 h) and 15 ^{o}C at night (8 h) and pots were watered to maintain approximate field capacity.

3.2 Soil and Vegetation Measurements

Prior to starting the greenhouse experiment, five composite samples of each of the substrates and amendments were submitted to a commercial laboratory and analyzed for pH, sodium adsorption ratio, electrical conductivity, total carbon, total nitrogen, major and minor nutrients, cation exchange capacity, particle size and major and trace metals. Three composite samples of each treatment were submitted to the laboratory for the same analyses.

Germination (via plant emergence) was monitored every three to four days for the first two weeks and density and health were measured every week for twelve weeks. Health was evaluated using a five point scale; a rating of five for healthy and vigorously growing plants, four for mostly healthy (could have brown tips on all or a few plants), three for 50 % healthy and 50 % dying or in poor health, two for mostly dying and one for dead.

In the final week, height of three representative plants in each pot was measured and a mean height per pot calculated. Above ground biomass in each pot was clipped, oven dried at 80 ^{o}C for 48 h and weighed. In three *Agropyron trachycaulum* pots of each treatment, below ground biomass was separated from the soil, washed, oven dried at 80 ^{o}C for 48 h and weighed.

3.3 Statistical Analyses

Mean height, percent germination and percent plant establishment were calculated for each pot. Data were tested for normality and homogeneity of variance prior to statistical analyses. Parametric methods were employed for soil data and non-parametric methods for plant response data due to heteroscedasticity. Two way analysis of variance (ANOVA) was conducted, with processed kimberlite type and amendment as fixed factors, to determine if there were differences in soil and plant response. If the overall test was significant, post hoc LSD tests (parametric) or Mann Whitney U tests (non-parametric) were conducted.

Due to differences in growth form and phenology among plant species, a separate ANOVA was conducted for each species. General comparisons between species were based on means and standard errors. A p value of 0.05 was used for all tests. In results and discussion, the word significant is used to denote analyses that were statistically significant.

4. RESULTS AND DISCUSSION

4.1 Characterization of Processed Kimberlite

The fine processed kimberlite from Orion and Star ore bodies were classified as sandy loam texture while the mix of coarse processed kimberlite from both ore bodies was classified as sand (Table 1). Sand content was highest in the mixed processed kimberlite. Clay content differed among processed kimberlite types from greatest to least as Orion > Star > Mix.

The lower clay content was expected based on the mix being of coarse Star and Orion processed kimberlites. The clay contents between the coarse and fine processed kimberlites are different enough to potentially impact their performances as substrates. These clay contents could impact physical, chemical and biological properties of the substrates as related to water holding capacity, percolation and infiltration rates and cation exchange capacity, which in turn could affect nutrient and water availability to plants.

All processed kimberlites were alkaline with similar pH from 8.6 to 9.3 (Table 1). These values would be considered poor for reclamation substrates and may affect pH sensitive plant species. Above pH 8, some plant nutrients may be deficient for some species.

Electrical conductivities were 3.2, 3.5 and 5.3 dS m^{-1} for Star, Orion and mixed processed kimberlite, respectively (Table 1). These values are unlikely to be limiting for most plant species. Electrical conductivities greater than 4 dS m^{-1} are considered slightly saline by agricultural standards and may impact salt sensitive plants. Electrical conductivities between 4 and 8 dS m^{-1} are considered poor for reclamation soil quality. The mixed processed kimberlite is in the lower range of these vales with potential for impact on salt sensitive species.

Sodium adsorption ratios were wide ranging, with Star processed kimberlite having the lowest 17.8) and mixed processed kimberlite having the highest (95.9) (Table 1). Ratios greater than 12 are considered unsuitable for reclamation substrates and can seriously limit plant growth for many species. Ratios between 12 and 15 can significantly impact soil physical properties, potentially restricting water and nutrient uptake by plants. The large concentration of sodium in the mixed processed kimberlite could lead to potential soil physical property issues, particularly as related to dispersion of clay particles affecting water and nutrient movement. While dispersion caused by high sodium adsorption ratios is a more serious concern in clay soil than sandy soils (Miller and Donahue 1995), it is an issue to be addressed with amendments.

Cation exchange capacity varied, being significantly highest in mixed processed kimberlite (40.7 meq 100 g^{-1}) and significantly lowest in Star processed kimberlite (5.3 meq 100 g^{-1}) (Table 1). Cation exchange capacity is usually higher in materials with higher clay content, so it is interesting that the mixed processed kimberlite, with the least amount of clay content has the highest values. Orion and Star processed kimberlite have quite different mineralogical compositions, which likely affected the cation exchange capacity. Montmorillonite, which is associated with a high cation exchange capacity, is most dominant in Orion processed kimberlite and does not occur in Star processed kimberlite. The coarser mix likely had high montmorillonite from the Orion component of the mix. Since primary minerals are reduced with weathering, the more weathered fine processed kimberlites would also have lower cation exchange capacity.

Larger cation exchange capacities indicate that a soil has a greater capacity to hold cations. Therefore, it requires higher rates of fertilizer or lime to change a high cation exchange capacity soil, but can offer a large nutrient reserve. Low cation exchange capacity soils hold fewer

nutrients, and may be subject to leaching of mobile anion nutrients. These soils may benefit from split applications of several nutrients.

Total carbon and nitrogen were low in all processed kimberlite types (Table 2). Star processed kimberlite had less total carbon then the other two types, although values are similar from a biological perspective. The mixed processed kimberlite had highest total sodium and calcium concentrations while Star processed kimberlite had highest total magnesium and potassium concentrations. All processed kimberlite types were very low in available phosphorus; Orion and Star were also very low in available nitrogen. Available sulphur and potassium concentrations were high, with highest concentrations in mixed and lowest in Star processed kimberlite. Thus plant nutrient availability will likely vary considerably depending on the substrate material used and this will need to be supplemented with amendments. Available micro nutrients copper, zinc, manganese and iron were similar in the types of processed kimberlites, except for lower manganese in Star and lower iron in mixed processed kimberlites (Table 2).

Nickel and chromium and cobalt exceeded Canadian Council of Ministers of the Environment soil quality guidelines in all three processed kimberlite types (Table 3). Exceedances were very high for nickel and chromium in all three processed kimberlites. This is comparable to processed kimberlite from other mine sites (Baker 2001, Reid and Naeth 2005a, 2005b, Drozdowski et al. 2011). Soils developed from ultrabasic rocks are usually enriched in chromium, cobalt, nickel and zinc (Anderson et al. 1973, Adriano 2001); therefore, soils derived from kimberlite will be elevated in these elements. Although elements such as chromium, cobalt, nickel and zinc are considered essential micro nutrients in low concentrations, at high concentrations they can be toxic to plants, animals and humans. Chromium has been found in kimberlite materials at other mine sites and was not taken up by plants or leached (Stevens 2006), therefore elevated concentrations are not likely to limit plant growth or result in negative environmental impacts. The low organic matter in processed kimberlite could increase metal mobilization, although the high pH would likely reduce toxicity potential. Orion processed kimberlite had highest concentrations of arsenic, chromium and copper; Star processed kimberlite had highest concentrations of nickel; the mixed processed kimberlite had highest concentrations of barium.

4.2 Effect of Amendments

The native sand, agricultural soil, yard compost and biosolids compost amendments each had potential to improve physical and chemical properties of the three processed kimberlite types.

They were specifically expected to lower pH, electrical conductivity and sodium adsorption ratio and to increase available nitrogen and phosphorus.

Agricultural soil was loamy sand textured with good chemical properties (Table 4). Native sand had potential to enhance soil structure and reduce pH, electrical conductivity and sodium adsorption ratio. Yard compost had highest electrical conductivities at 10.7 dS m^{-1}; biosolids compost had electrical conductivities of 6 dS m^{-1}. These values may be high enough to affect salt sensitive plant species. Amendment pH and sodium adsorption ratios for all amendments were within ranges to provide no problems for vegetation.

Agricultural soil had good available nitrogen and phosphorus (Table 5). Native sand had low available nutrients. Both composts had high available nutrients although concentrations in yard compost were significantly greater than those in biosolids compost. Sulphate and phosphate concentrations in yard compost and potassium in both yard and biosolids composts may be high enough to be detrimental to some plants. Yard compost had significantly more total carbon and total nitrogen than other amendments including biosolids compost.

Metal concentrations in agricultural soil and native sand were well below any soil quality guidelines and therefore not a concern (Table 6). Metal concentrations in both composts were acceptable according to Canadian Council of Ministers of the Environment Guidelines for Compost Quality for Category B compost; however, molybdenum, selenium and mercury were above acceptable concentrations for Category A compost (Canadian Council of Ministers of the Environment 2005).

For most soil properties the interaction of processed kimberlite type and amendment was statistically significant. Amendments, with the exception of compost, significantly decreased silt content of Orion and Star processed kimberlite (Table 7). Agricultural soil and sand increased silt content in mixed processed kimberlite. Sand amendment significantly increased sand content of Orion and Star processed kimberlite, but not mixed processed kimberlite. Orion processed kimberlite had significantly more clay than when amended, while Star processed kimberlite had significantly more clay than when amended with agricultural soil and sand. Soil texture in all cases was acceptable for reclamation, although the high sand contents in the mixed processed kimberlite, with any of the amendments, have potential to limit water and nutrient retention.

All amendments significantly decreased pH of processed kimberlite (Table 8). Although pH was lower with amendment, it was not always sufficiently lowered to have much of an impact on

vegetation. Most biologically significant reductions occurred with yard compost amendment of Orion and mixed processed kimberlite, and any amendment of Star processed kimberlite.

Sand significantly decreased electrical conductivity in Orion and mixed processed kimberlite, but not Star processed kimberlite (Table 8). Yard compost significantly increased electrical conductivity in all three types and biosolids compost increased electrical conductivity of Orion and Star processed kimberlites. Electrical conductivity was only high enough to be of concern for vegetation in compost amended processed kimberlite. However, electrical conductivity tends to decrease very quickly as salts leach from the composts. So these higher values would not preclude use of composts for reclamation.

All amendments significantly decreased sodium adsorption ratio of all processed kimberlites (Table 8). Values were still very high in most amended Orion and mixed processed kimberlites, but relatively better in amended Star processed kimberlites.

All amendments except yard compost significantly decreased cation exchange capacity of mixed and Orion processed kimberlite (Table 8). Yard and biosolids composts significantly increased cation exchange capacity of Star processed kimberlite. This illustrates the value of compost in amending kimberlites, even with the higher short term electrical conductivities.

Amendments impacted total, available and micro nutrients (Tables 9, 10, 11). Regardless of processed kimberlite type, yard and biosolids composts significantly increased total carbon and nitrogen, while sand significantly decreased both relative to unamended. Treatments where agricultural soil was added were not significantly different from unamended processed kimberlite. Adding yard compost to mixed and Orion processed kimberlite resulted in significantly greater available nitrate than in all other amended treatments. Yard and biosolids compost significantly increased available potassium, total carbon and total nitrogen. Sand significantly decreased available sulphate in Orion and mixed processed kimberlite and biosolids compost in mixed processed kimberlite only. Biosolids compost increased sulphate in Orion and Star processed kimberlite. Sand decreased sodium in mixed and Orion processed kimberlite. The two composts significantly increased total calcium, potassium and magnesium cations in each processed kimberlite type. Biosolids compost significantly decreased sodium in mixed processed kimberlite, while yard compost increased concentrations in all three types. Agricultural soil had little effect on the nutrient status of the three processed kimberlite types. In general nutrient status was most enhanced by composts. Yard and biosolids compost significantly increased manganese concentrations and biosolids compost increased iron

concentrations when added to each processed kimberlite type. Thus nutrient status was affected by amendments but the effect varied with processed kimberlite and amendments.

Amendments significantly reduced cobalt, nickel and vanadium concentrations in each processed kimberlite (Tables 12a, 12b and 12c). Yard compost amended processed kimberlite had significantly greater concentrations of these metals than with other amendments. Nickel concentrations in all treatments were greater than Canadian Council of Ministers of the Environment soil quality guidelines (Canadian Council of Ministers of the Environment 2007). Amendment with agricultural soil or sand decreased cobalt concentrations in Orion and mixed processed kimberlite so they were below guidelines; cobalt remained at or above Canadian Council of Ministers of the Environment guidelines in all Star processed kimberlite treatments. Processed kimberlite alone had significantly higher barium and chromium concentrations than amended treatments, and significantly greater copper and lead than agricultural soil or sand amended treatments. Yard compost significantly increased copper and lead compared to other treatments. Chromium concentrations were above Canadian Council of Ministers of the Environment guidelines for soil quality in all treatments and copper concentrations in compost amended treatments (Canadian Council of Ministers of the Environment 2007). Barium and lead concentrations were well below soil quality guidelines.

4.3 Response of Agronomic Forages

Germination of *Bromus elatior* was lower in unamended Orion (62 %) and mixed (64 %) processed kimberlites than in Star (84 %) processed kimberlite (Tables 13, 14, 15). Germination for *Hordeum vulgare* was similar in all three unamended processed kimberlites (84 to 90 %). Germination in the reference potting soil for each species averaged 80 and 90 %, respectively.

None of the amendments in this study improved *Bromus elatior* germination in Star processed kimberlites, but germination rate dropped by 8 to 28 % relative to the unamended processed kimberlite (Tables 13, 14, 15). In Orion and mixed processed kimberlites, amendment with agricultural soil or native sand increased germination rate by 10 to 20 %. Amending Orion processed kimberlite with fertilizer, yard composts and biosolids compost had little impact, dropping germination slightly. In mixed processed kimberlites these three amendments dropped germination significantly. *Hordeum vulgare* germination increased slightly with amendment with agricultural soil in Orion and mixed processed kimberlites and decreased by 10 % in Star processed kimberlites. Native sand amendment increased germination in all processed kimberlites. Fertilizer and compost decreased germination *Hordeum vulgare* in Star and mixed

processed kimberlites, while fertilizer increased germination in Orion processed kimberlite and biosolids compost had no effect.

Establishment of *Bromus elatior* was relatively unaffected by amendment in all processed kimberlites, except it was reduced by biosolids compost in mixed processed kimberlite (Tables 13, 14, 15). Establishment of *Hordeum vulgare* increased in all processed kimberlites with compost amendment; native sand and fertilizer had less impact and agricultural soil decreased germination in Star processed kimberlite.

Hordeum vulgare is relatively salt tolerant while *Bromus elatior* is more sensitive to salts. This likely contributed to the different responses of the two plant species to processed kimberlites and amendments. Germination was more impacted by processed kimberlite type and amendment than establishment. Age can be a significant factor in salt tolerance, explaining the more dramatic responses of germination than establishment.

Bromus elatior and *Hordeum vulgare* plants had significantly greater density, height and biomass in Star processed kimberlite than in Orion or mixed processed kimberlite (Tables 16, 17, 18). In Orion processed kimberlite with fertilizer and agricultural soil had no effect on *Hordeum vulgare* density, while composts and sand significantly increased density. Amendment had no effect on *Bromus elatior* density. Plants were taller when amendments were added. All amendments increased above ground biomass considerably compared to the unamended processed kimberlites. Biomass was most increased with composts in all three processed kimberlites for both plant species.

Health of *Hordeum vulgare* plants declined at 8 weeks as plants became root bound in the pot, not related to impacts of processed kimberlite or amendments. At 8 weeks, plants were healthy and vigourous; by week 12 the mean health rating ranged from 1.8 in unamended processed kimberlite to 3.3 in yard compost and processed kimberlite. Leaves gradually developed brown tips, which then yellowed in colour. Plants in all treatments set seed around week 9 regardless of declining health. Mean health rating for *Bromus elatior* was 3.0 in unamended processed kimberlite and 4.3 in biosolids compost. None set seed.

4.4 Response of Native Grasses

Germination for native grass species in unamended processed kimberlite was 77 to 88 % for *Agropyron trachycaulum* (81 % in reference potting soil), 34 to 70 % *Elymus innovatus* (56 % in reference potting soil), 17 to 41 % *Festuca saximontana* (63 % in reference potting soil) and 3 to

29 % for *Koeleria macrantha* (57 % in reference potting soil) (Tables 13, 14, 15). The interaction between processed kimberlite type and amendment significantly influenced most of the species.

Agropyron trachycaulum germination was most affected by yard compost in Orion, fertilizer and composts in Star and all amendments in mixed processed kimberlites (Tables 13, 14, 15). Germination of *Elymus innovatus* was most affected by yard compost in Orion and fertilizer in mixed processed kimberlites. Germination of *Festuca saximontana* was reduiced by all amendments in Star processed kimberlite and most increased by biosolids compost in Orion and by all but the composts in mixed processed kimberlite. Germination of *Koeleria macrantha* increased with all amendments in Orion processed kimberlite and decreased with fertilizer and composts in Star processed kimberlite. In mixed processed kimberlite germination increased with agricultural soil and native sand and decreased with composts.

Establishment of native grasses was affected by amendments and processed kimberlites (Tables 13, 14, 15). Establishment was high for *Agropyron trachycaulum* and relatively unaffected by amendment. This is not unexpected for this robust and tolerant species. Establishment of *Elymus innovatus* increased with sand, fertilizer and composts in Orion and Star processed kimberlites; it decreased with agricultural soil and fertilizer and increased with sand and composts in mixed processed kimberlite. Establishment of *Festuca saximontana* increased with agricultural soil, fertilizer and composts in Orion processed kimberlite. It decreased with all amendments in Star processed kimberlite and increased with all but fertilizer in mixed processed kimberlite. Establishment of *Koeleria macrantha* was improved with all amendments in Orion and mixed processed kimberlites, but only with sand and fertilizer in Star processed kimberlite. Establishment rates, like germination, were very low for *Koeleria macrantha* suggesting soil conditions were not favourable for this species.

The effect of processed kimberlite type and amendment on above ground biomass, height and density varied greatly with plant species (Tables 16, 17, 18). *Agropyron trachycaulum* density declined with yard compost in Orion and fertilizer and biosolids compost in mixed processed kimberlites. Height increased in all but fertilizer amended mixed processed kimberlite. Amendments alone, particularly composts, significantly increased *Agropyron trachycaulum* biomass. Processed kimberlite type and amendments impacted *Elymus innovatus* height, density and biomass. All amendments increased height and biomass, except biomass in fertilized mixed processed kimberlite. *Festuca saximontana* density varied considerably with amendments and processed kimberlites. Height increased with all amendments, except native sand in Orion and fertilizer in mixed processed kimberlites. Biomass increased with

amendments, except for native sand and fertilizer in Orion, and fertilizer in mixed processed kimberlites. *Koeleria macrantha* density increased with all amendments in Orion, decreased with all amendments except native sand in Star and decreased with all amendments except agricultural soil and native sand in mixed processed kimberlite. Height increased with all amendments except fertilizer in Orion, and only increased with native sand in Star and agricultural soil in mixed processed kimberlites.

Only below ground biomass from *Agropyron trachycaulum* was sampled and weighed. Mean biomass in the unamended treatments was 0.410 g, 0.549 g and 0.580 g for Orion, Star and mixed processed kimberlite, respectively. Type of processed kimberlite did not affect below ground biomass. Amendments increased below ground biomass, although only yard compost (0.823 g), biosoilds compost (0.838 g) and sand (0.455 g) did so significantly.

Agropyron trachycaulum was the only species to set seed at around 10 weeks. In general health ratings slightly declined at 8 to 10 weeks. Tips of plants browned and some leaves yellowed, particularly in the unamended treatment (Photos 1 to 4). These morphological changes, however, were not detrimental to plant survival.

4.5 Response of Native Trees

Populus tremuloides was selected as a potential species for reclamation due to its high germination, rapid growth and dominance in forests surrounding the mine site. In germination tests, 100 % of the seed germinated within 48 hours. In the greenhouse, germination was lower than expected even in the reference potting soil (31.1 %). Of the reclamation treatments, germination was greatest in Orion processed kimberlite amended with agricultural soil (24.0 %), followed by Star processed kimberlite amended with biosolids compost (17.3 %) and agricultural soil (10.7 %). In reclamation treatments seedlings died within 2 weeks. Seedlings survived the 12 week experiment in potting soil with a mean density of 4.7 plants per pot and mean height of 20.7 cm. The mean health rating was 3.75 and was reduced slightly as seedlings became pot bound. This low success with this species will need to be investigated to determine if greenhouse conditions were not favourable, since even the potting soil control did not do well.

4.6 Reclamation of Processed Kimberlites

In general, and not unexpectedly, plant species performance in each of the three processed kimberlite types was relatively unique. To assess reclamation potential and amendment needs

of each of the three processed kimberlites, some overall trends must be interpreted. One can assume that for effective revegetation, germination, establishment and biomass production are the plant parameters of general importance. Evaluating these within and between processed kimberlites and amendments will provide a general trend for reclamation treatments most likely to be effective.

Differences in physical properties among processed kimberlite types likely had a considerable impact on plant response. Mixed processed kimberlite, which had high sand and low clay content, resulted in lowest germination and plant densities for agronomic and most native species and Star processed kimberlite, which had moderate sand and clay, the highest. Sandy loam to loamy sand textures of Orion and Star processed kimberlites would improve nutrient and water retention over sand textured mixed processed kimberlite. Mixed processed kimberlite had high available nitrogen and cation exchange capacity, theoretically providing good conditions for plant growth, however, the physical and chemical limitations such as extreme sodium adsorption ratio and high electrical conductivity likley negated some of these potential benefits. If coarse processed kimberlites were to be used for reclamation substrates they would benefit from mixing with finer processed kimberlites and more heavy amendment applications.

For the mixture of coarse processed kimberlite, germination and final plant performance was greatest in sand amended treatments. Agricultural soil also improved germination of most species, with the exception of *Agropyron trachycaulum* and *Elymus innovatus*, and increased the final density of *Festuca saximontana* and *Koeleria macrantha*. Final density of *Hordeum vulgare* was greatest in compost amended treatments. Fertilizer amendment was detrimental to germination and establishment of *Agropyron trachycaulum*, *Bromus elatior* and *Elymus innovatus*; had no effect on *Koeleria macrantha*; and increased germination but not final density of *Festuca saximontana*. Yard compost resulted in highest above ground biomass for *Agropyron trachycaulum*. Highest biomass of *Elymus innovatus* and *Festuca saximontana* was produced in biosolids compost and *Koeleria macrantha* in treatments amended with agricultural soil.

While cation exchange capacity and total carbon were low in Star processed kimberlite, its physical composition and lower sodium adsorption ratio were more suitable for plant growth. Star and Orion processed kimberlites had significantly elevated concentrations of certain metals compared to mixed processed kimberlite, but these do not seem to have inhibited plant growth.

Revegetation of fine processed kimberlite in the Northwest Territories was not successful without amendment (Reid and Naeth 2005a, 2005b; Naeth and Wilkinson unpublished) and

even then plant densities were lower than other reclamation treatments and declined over a five year period (Naeth and Wilkinson unpublished). These tailings had similar nutrient and metal limitations to Shore Gold processed kimberlite, although sodium adsorption ratio and electrical conductivities were more amenable for plant growth. In this greenhouse study, the addition of amendments improved plant response for Orion and mixed processed kimberlite types but in general not Star processed kimberlite.

When amending fine processed kimberlite from the Orion deposit, sand significantly enhanced germination and final plant densities of *Agropyron trachycaulum, Bromus elatior* and *Koeleria macrantha*. Sand also enhanced germination of *Elymus innovatus*, however, the unamended treatment provided similar final densities as sand, fertilizer or biosolids compost. Agricultural soil also enhanced *Bromus elatior* and *Hordeum vulgure* germination. For above ground biomass production, there was agreement among species in their response. Reclamation treatments had the following order for biomass, biosolids compost > yard compost > agricultural soil.

Amendments did not always improve plant response in Star processed kimberlite. The unamended treatment had the highest, or similar to other treatments, germination and density. Mean plant heights and aboveground biomass were greater in biosolids compost and yard compost treatment with the exception of *Koeleria macrantha*, where sand treatments resulted in the tallest plants and greatest biomass. High amounts of biomass were also obtained in fertilizer treatments for *Hordeum vulgare* and *Koeleria macrantha*, sand for *Elymus innovatus* and *Festuca saximontana* and agricultural soil for *Agropryon trachycaulum* and *Bromus elatior*.

4.7 Species Selection for Reclamation

Species growth form appears to impact plant response to reclamation treatments. Short, tufted species, *Festuca saximontana* and *Koeleria macrantha*, often responded in the same way to a particular processed kimberlite type or amendment. *Hordeum vulgare*, an agronomic forage developed for optimum production in an agricultural setting, was able to tolerate the poor chemical conditions of treatments more readily than the native species. While *Bromus elatior* is also an agronomic forage, it responded more similarly to *Agropyron trachycaulum* than *Hordeum vulgare*. *Agropyron trachycaulum*, a native bunch grass, is known to be fairly tolerant of saline and low nutrient conditions compared to other native species. *Elymus innovatus*, also a native bunch grass, responded similarly to *Agropyron trachycaulum* for many parameters measured, however, overall it had much lower germination, density and biomass, reflecting a lower tolerance to poor growing conditions. Including a diversity of plant species in a seed mix,

increases community species richness. Even if reclamation sites are initially dominated by a few species, the increased species richness may in time improve soil and site conditions and overall reclamation success.

5. CONCLUSIONS

Based on this initial greenhouse study, the following can be reported:

- Agronomic and native plant species will establish in unamended fine processed kimberlite from the Star and Orion-South deposits and a mix of coarse processed kimberlite from both deposits.
- The three processed kimberlites tested had different physical and chemical compositions which affected plant response.
- Star fine processed kimberlite unamended had higher germination and plant densities than Orion fine processed kimberlite or the mix of coarse processed kimberlites. The mix of coarse processed kimberlites consistently had the lowest plant response.
- Reclamation treatments that resulted in the tallest plants and greatest aboveground biomass were not the same ones that provide the highest germination or final plant densities.
- The addition of native sand or agricultural soil enhanced germination and final plant density.
- The addition of yard compost or biosolids compost increased aboveground biomass in each type of processed kimberlite.
- *Koeleria macrantha* had the poorest performance of the plant species tested. *Festuca saximontana*, a reclamation species that does well on many disturbed sites, also did not perform well in treatments.

6. FUTURE RESEARCH

Further research is justified based on results from this preliminary greenhouse study. Differences in plant response to processed kimberlite types are not fully understood and will ultimately affect reclamation success. Potential benefits of adding multiple amendments should be investigated to determine optimal techniques to address physical and chemical limitations while enhancing beneficial properties of various processed kimberlites. The most likely end land use will be native boreal forest, similar to that currently found surrounding the Star Orion-South Diamond Project, and therefore woody species including boreal trees and shrubs should be tested for establishment and survive in amended processed kimberlite substrates.

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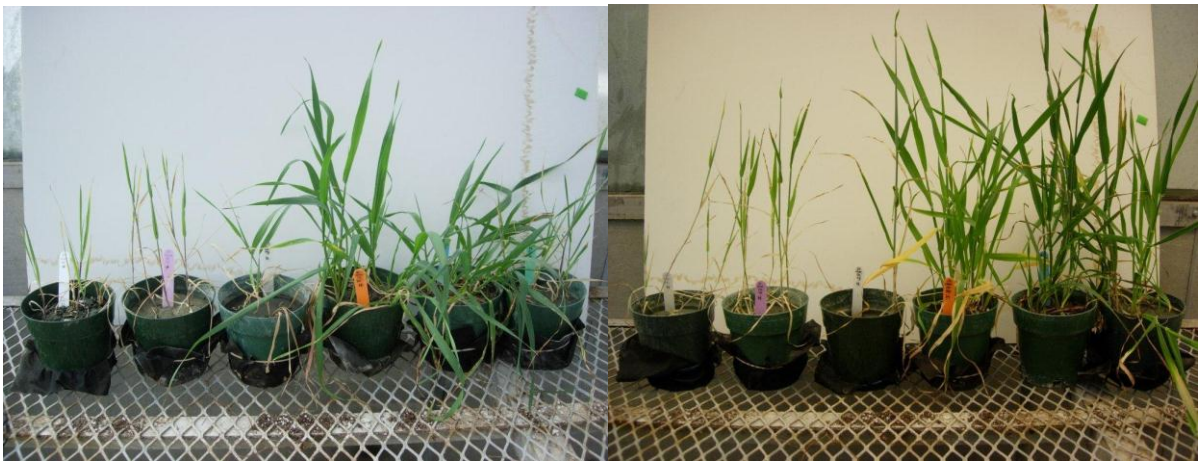

Photo 1. *Hordeum vulgare* (barley) grown in Orion (left) and Star (right) fine processed kimberlites. Treatments in each photo, from left to right are unamended, sand amended, agricultural soil, biosolids compost, yard compost, inorganic fertilizer.

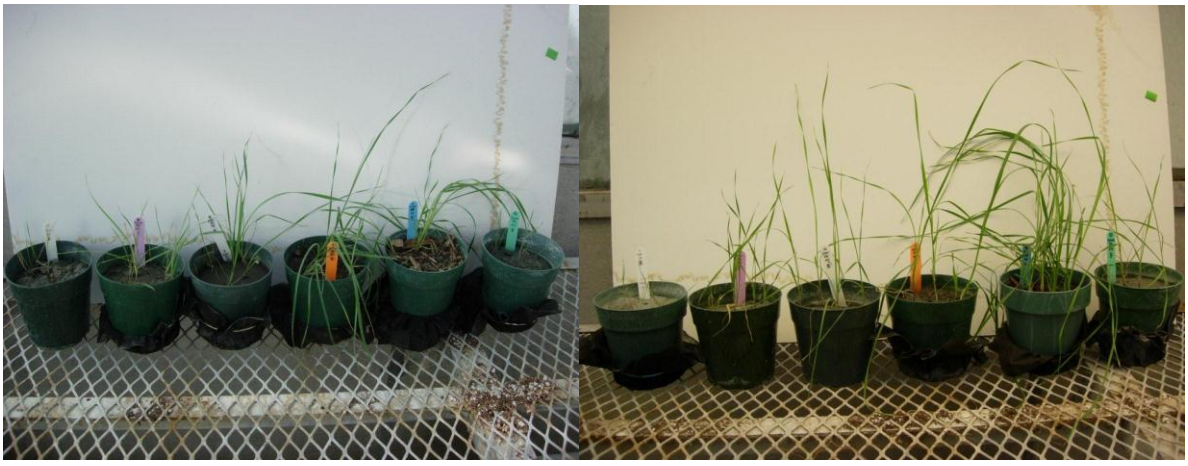

Photo 2. *Bromus elatior* (meadow brome) grown in Orion (left) and Star (right) fine processed kimberlites. Treatments from left to right in each photo are unamended, sand amended, agricultural soil, biosolids compost, yard compost, inorganic fertilizer.

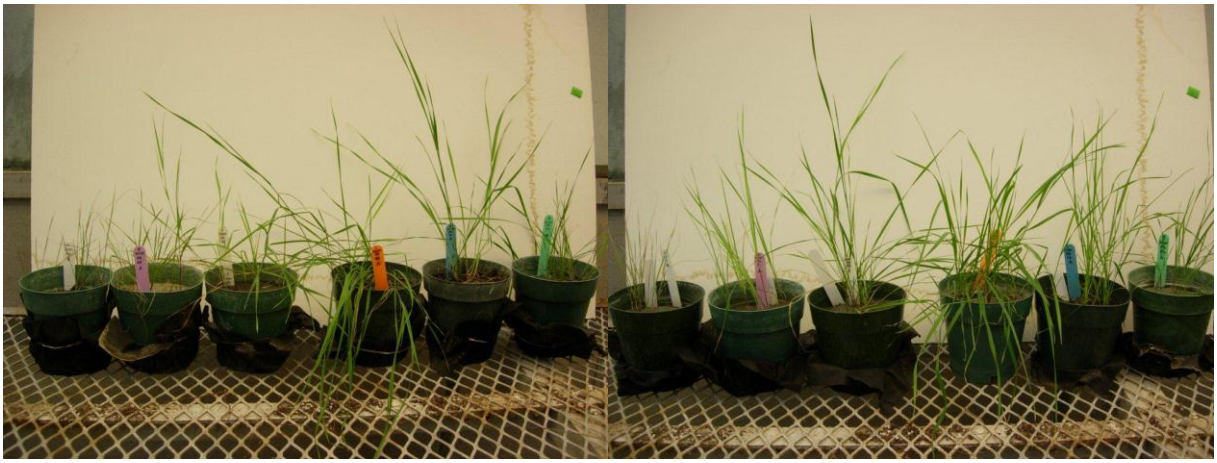

Photo 3. *Agropyron trachycaulum* (slender wheatgrass) grown in Orion (left) and Star (right) fine processed kimberlites. Treatments from left to right in each photo are unamended, sand amended, agricultural soil, biosolids compost, yard compost, inorganic fertilizer.

Photo 4. *Elymus innovatus* (hairy wild rye) grown in Orion (left) and Star (right) fine processed kimberlites. Treatments from left to right in each photo are unamended, sand amended, agricultural soil, biosolids compost, yard compost, inorganic fertilizer.

Table 1. Physical and chemical properties of unamended processed kimberlites.

Parameter	Orion Fine	Star Fine	Orion Star Mixed Coarse
Sand (%)	66.2 (2.7)	70.0 (1.3)	90.9 (0.3)
Silt (%)	20.2 (1.1)	20.7 (1.3)	4.9 (0.2)
Clay (%)	13.6 (1.7)	9.8 (0.3)	4.2 (0.2)
Texture	Sandy loam	Sandy loam	Sand
Hydrogen Ion Concentration (pH)	9.1 (0.1)	8.6 (0.0)*	9.3 (0.0)*
Electrical Conductivity (dS m^{-1})	3.5 (0.2)	3.2 (0.2)	5.8 (0.4)
Sodium Adsorption Ratio	74.4 (16.7)	17.8 (0.9)	95.9 (2.1)
Cation Exchange Capacity (meq 100 g^{-1})	22.1 (2.3)	5.3 (0.2)	40.7 (0.7)
Saturation (%)	80.2 (11.5)	46.6 (1.7)	38.4 (0.7)

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

Table 2. Macro and micro nutrient properties of unamended processed kimberlites.

Parameter	Orion Fine	Star Fine	Orion Star Mixed Coarse
Total Carbon (%)	1.2 (0.1)	0.9 (0.0)*	1.0 (0.1)
Total Nitrogen (%)	0.0* (0.0)	0.0* (0.0)	0.0* (0.0)
Total Calcium (mg L^{-1})	3.6 (0.7)	12.5 (0.8)	13.6 (2.5)
Total Magnesium (mg L^{-1})	5.0 (1.9)	42.7 (2.3)	3.0 (0.5)
Total Potassium (mg L^{-1})	19.8 (1.6)	32.1 (1.6)	23.2 (1.7)
Total Sodium (mg L^{-1})	823.8 (56.9)	591.8 (44.1)	1254.0 (87.8)
Available Nitrate (mg kg^{-1})	6.7 (0.6)	1.7 (0.5)	55.6 (5.2)
Available Phosphate (mg kg^{-1})	1.0 (0.0)	1.0 (0.0)	1.2 (0.2)
Available Potassium (mg kg^{-1})	206.4 (12.2)	119.8 (3.1)	307.0 (4.8)
Available Sulfate (mg kg^{-1})	121.7 (9.4)	93.2 (7.0)	202.8 (22.9)
Available Copper (mg kg^{-1})	1.8 (0.1)	1.3 (0.0)*	1.2 (0.1)
Available Zinc (mg kg^{-1})	1.3 (0.1)	0.9 (0.0)*	1.1 (0.1)
Available Manganese (mg kg^{-1})	4.3 (0.6)	1.5 (0.1)	4.7 (0.2)
Available Iron (mg kg^{-1})	31.6 (1.8)	33.3 (1.0)	9.1 (0.5)

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

Table 3. Total metal and selenium concentrations in processed kimberlites.

Parameter	Orion Fine	Star Fine	Orion Star Mixed Coarse
Antimony (mg kg^{-1})	0.1 (0.0)*	0.1 (0.0)	0.1 (0.0)
Arsenic (mg kg^{-1})	3.2 (0.6)	2.0 (0.1)	0.8 (0.0)*
Barium (mg kg^{-1})	211.8 (11.6)	209.6 (7.5)	268.8 (13.8)
Cadmium (mg kg^{-1})	0.3 (0.0)	0.0* (0.0)	0.0* (0.0)
Chromium (mg kg^{-1})	546.4 (41.6)	398.4 (13.8)	350.8 (26.0)
Cobalt (mg kg^{-1})	76.0 (6.0)	70.9 (1.0)	48.8 (1.3)
Copper (mg kg^{-1})	59.5 (7.0)	42.8 (2.6)	28.6 (1.8)
Lead (mg kg^{-1})	6.9 (0.4)	6.9 (0.2)	7.9 (0.3)
Molybdenum (mg kg^{-1})	3.1 (0.7)	1.4 (0.2)	0.5 (0.0)
Mercury (mg kg^{-1})	0.0* (0.0)*	0.0* (0.0)	0.0* (0.0)
Nickel (mg kg^{-1})	986.2 (76.6)	1346.0 (60.1)	670.8 (15.4)
Selenium (mg kg^{-1})	0.3 (0.0)	0.3 (0.0)	0.2 (0.0)
Silver (mg kg^{-1})	0.5 (0.0)	0.5 (0.0)	0.5 (0.0)
Tin (mg kg^{-1})	2.5 (0.0)	2.5 (0.0)	2.5 (0.0)
Uranium (mg kg^{-1})	1.0 (0.0)	1.0 (0.0)	1.6 (0.4)
Vanadium (mg kg^{-1})	74.8 (7.6)	50.0 (1.7)	49.2 (0.9)
Zinc (mg kg^{-1})	46.8 (2.5)	46.6 (1.3)	41.8 (1.0)

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

Table 4. Physical and chemical properties of soil amendments.

Parameter	Agricultural Soil	Native Sand	Yard Compost	Biosolids Compost
% Sand	85.1 (0.9)	94.5 (0.2)	69.0 (5.5)	84.6 (1.0)
% Silt	10.9 (1.2)	2.6 (0.3)	27.9 (5.0)	11.4 (0.8)
% Clay	4.1 (0.3)	2.9 (0.3)	3.1 (0.8)	4.0 (0.3)
Texture	Loamy sand	Sand	Sandy loam	Loamy sand
Hydrogen Ion Concentration (pH)	7.0 (0.0)*	7.3 (0.0)*	6.5 (0.1)	7.6 (0.0)*
Electrical Conductivity (dS m^{-1})	1.0 (0.1)	0.1 (0.0)*	10.7 (0.5)	6.0 (0.1)
Sodium Adsorption Ratio	0.2 (0.1)	0.6 (0.0)*	1.5 (0.1)	0.6 (0.0)*
Cation Exchange Capacity (meq 100 g^{-1})	5.9 (0.3)	2.2 (0.1)	30.8 (2.4)	11.4 (0.7)
Saturation (%)	29.9 (0.5)	27.0 (0.6)	234.8 (4.9)	58.2 (1.1)

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

Table 5. Macro and micro nutrient properties of soil amendments.

Parameter	Agricultural Soil	Native Sand	Yard Compost	Biosolids Compost
Total Carbon (%)	1.0 (0.0)	0.2 (0.0)*	16.9 (0.2)	3.9 (0.1)
Total Nitrogen (%)	0.1 (0.0)*	0.0* (0.0)	1.9 (0.0)*	0.4 (0.0)*
Total Calcium (mg L^{-1})	129.2 (8.9)	11.9 (0.6)	166.4 (17.3)	251.0 (3.4)
Total Magnesium (mg L^{-1})	23.5 (1.4)	3.3 (0.2)	203.6 (34.1)	115.0 (1.8)
Total Potassium (mg L^{-1})	35.2 (2.3)	3.6 (0.1)	547.6 (22.9)	1154.0 (40.6)
Total Sodium (mg L^{-1})	5.1 (0.4)	8.4 (0.8)	123.2 (5.2)	48.2 (0.9)
Available Nitrate (mg kg^{-1})	26.3 (2.0)	1.0 (0.0)*	734.6 (69.2)	196.8 (6.1)
Available Phosphate (mg kg^{-1})	52.4 (3.1)	12.8 (0.7)	6566.0 (217.3)	277.2 (12.0)
Available Potassium (mg kg^{-1})	157.6 (4.8)	38.2 (0.6)	2448.0 (84.5)	1996.0 (39.4)
Available Sulfate (mg kg^{-1})	3.4 (0.2)	1.7 (1.7)	1374.0 (10.3)	43.42 (2.0)
Available Copper (mg kg^{-1})	0.2 (0.0)*	0.1 (0.0)*	62.7 (0.6)	0.7 (0.0)*
Available Zinc (mg kg^{-1})	0.4 (0.0)*	0.2 (0.0)*	79.1 (0.9)	6.0 (0.2)
Available Manganese (mg kg^{-1})	2.7 (0.1)	1.3 (0.0)*	72.4 (1.3)	8.5 (0.9)
Available Iron (mg kg^{-1})	15.5 (0.3)	15.8 (0.4)	149.5 (10.3)	58.5 (3.0)

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

Table 6. Metal and selenium concentrations in soil amendments.

Parameter	Agricultural Soil	Native Sand	Yard Compost	Biosolids Compost
Antimony (mg kg^{-1})	0.1 (0.0)*	0.1 (0.0)	2.0 (0.1)	0.6 (0.4)
Arsenic (mg kg^{-1})	2.4 (0.0)*	3.3 (0.1)	3.2 (0.1)	3.2 (0.1)
Barium (mg kg^{-1})	46.0 (0.9)	45.1 (1.5)	218.0 (7.0)	72.0 (2.2)
Cadmium (mg kg^{-1})	0.0* (0.0)	0.0* (0.0)	1.0 (0.0)*	0.0* (0.0)
Chromium (mg kg^{-1})	6.3 (0.9)	5.6 (0.1)	20.4 (0.7)	7.9 (0.6)
Cobalt (mg kg^{-1})	2.9 (0.1)	3.6 (0.1)	3.5 (0.1)	3.6 (0.2)
Copper (mg kg^{-1})	4.1 (0.2)	2.8 (0.1)	312.8 (12.8)	10.6 (0.3)
Lead (mg kg^{-1})	2.5 (0.0)	2.5 (0.0)	24.5 (1.1)	55.6 (49.1)
Molybdenum (mg kg^{-1})	0.5 (0.0)	0.5 (0.0)	6.3 (0.3)	0.5 (0.0)
Mercury (mg kg^{-1})	0.0* (0.0)	0.0* (0.0)*	1.0 (0.1)	0.0* (0.0)
Nickel (mg kg^{-1})	5.4 (0.1)	9.0 (0.7)	15.9 (0.6)	8.9 (0.4)
Selenium (mg kg^{-1})	0.3 (0.0)	0.3 (0.0)	2.1 (0.1)	0.3 (0.0)
Silver (mg kg^{-1})	0.5 (0.0)	0.5 (0.0)	6.3 (0.3)	0.5 (0.0)
Tin (mg kg^{-1})	2.5 (0.0)	2.5 (0.0)	14.0 (0.5)	2.5 (0.0)
Uranium (mg kg^{-1})	1.0 (0.0)	1.0 (0.0)	6.8 (0.3)	1.0 (0.0)
Vanadium (mg kg^{-1})	10.6 (0.1)	8.6 (0.3)	13.7 (0.3)	11.7 (0.5)
Zinc (mg kg^{-1})	19.6 (1.0)	307.8 (12.7)	48.0 (1.3)	18.2 (2.7)

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

Table 7. Textural properties of processed kimberlite reclamation treatments.

Reclamation Treatment	% Sand	% Silt	% Clay	Texture
Orion PK	66.2 (2.7)	20.2 (1.1)	13.6 (1.7)	Sandy loam
Orion PK, Agricultural Soil	82.8 (2.1)	11.7 (0.7)	5.5 (1.5)	Loamy sand
Orion PK, Native Sand	88.0 (0.7)	7.1 (0.3)	4.9 (0.4)	Sand
Orion PK, Yard Compost	70.4 (0.2)	18.4 (0.3)	11.2 (0.1)	Sandy loam
Orion PK, Biosolids Compost	76.8 (0.4)	15.0 (0.6)	8.2 (0.2)	Sandy loam
Star PK	69.6 (1.3)	20.7 (1.3)	9.8 (0.3)	Sandy loam
Star PK, Agricultural Soil	78.7 (0.7)	13.8 (0.6)	7.5 (0.2)	Loamy sand
Star PK, Native Sand	83.9 (0.4)	9.7 (0.3)	6.4 (2.7)	Loamy sand
Star PK, Yard Compost	69.7 (0.6)	20.0 (0.5)	10.3 (0.2)	Sandy loam
Star PK, Biosolids Compost	73.1 (1.1)	17.6 (0.2)	9.4 (0.8)	Sandy loam
Mix PK	90.9 (0.3)	4.9 (0.2)	4.2 (0.2)	Sand
Mix PK, Agricultural Soil	88.6 (0.8)	7.9 (0.5)	3.5 (0.3)	Sand
Mix PK, Native Sand	92.8 (0.2)	3.8 (0.2)	3.4 (0.1)	Sand
Mix PK, Yard Compost	90.5 (0.1)	5.9 (0.2)	3.6 (0.2)	Sand
Mix PK, Biosolids Compost	88.8 (0.6)	7.9 (0.4)	3.3 (0.3)	Sand

Numbers in brackets are standard errors of mean.

PK = processed kimberlite

Table 8. Chemical properties of processed kimberlite reclamation treatments.

Reclamation Treatment	Hydrogen Ion Concentration (pH)	Electrical Conductivity (dS m^{-1})	Sodium Adsorption Ratio	Cation Exchange Capacity (meq 100 g^{-1})	% Saturation
Orion PK	9.1 (0.1)	3.5 (0.2)	74.4 (16.7)	22.1 (2.3)	80.2 (11.5)
Orion PK, Agricultural Soil	8.9 (0.0)	3.0 (0.1)	54.1 (7.9)	8.2 (0.4)	33.5 (0.5)
Orion PK, Native Sand	8.9 (0.0)	2.2 (0.1)	34.4 (1.1)	6.8 (1.0)	30.5 (1.2)
Orion PK, Yard Compost	8.4 (0.1)	8.2 (0.2)	32.4 (3.7)	23.9 (0.1)	80.2 (11.5)
Orion PK, Biosolids Compost	8.7 (0.0)	5.9 (0.1)	32.7 (0.3)	16.1 (0.4)	48.2 (0.5)
Star PK	8.6 (0.0)	3.2 (0.2)	17.9 (0.9)	5.3 (0.2)	46.6 (1.7)
Star PK, Agricultural Soil	8.1 (0.1)	3.6 (0.3)	11.5 (1.3)	5.5 (0.2)	32.9 (1.0)
Star PK, Native Sand	8.3 (0.0)	3.6 (0.1)	14.9 (0.3)	3.4 (0.2)	30.5 (1.2)
Star PK, Yard Compost	7.6 (0.1)	12.2 (0.4)	8.1 (0.6)	11.3 (1.1)	50.8 (2.3)
Star PK ,Biosolids Compost	8.2 (0.0)	7.6 (0.2)	11.8 (0.9)	9.5 (0.5)	42.4 (1.2)
Mix PK	9.3 (0.1)	5.9 (0.4)	95.9 (2.1)	40.7 (0.7)	38.4 (0.7)
Mix PK, Agricultural Soil	8.9 (0.0)	5.2 (0.1)	79.8 (2.9)	22.6 (1.2)	34.0 (1.3)
Mix PK, Native Sand	8.9 (0.0)	4.2 (0.3)	84.4 (2.8)	21.0 (1.3)	33.3 (0.3)
Mix PK, Yard Compost	8.0 (0.0)*	10.9 (0.3)	61.9 (1.6)	42.8 (0.9)	69.1 (2.3)
Mix PK, Biosolids Compost	8.7 (0.1)	5.4 (0.2)	31.6 (0.3)	20.8 (0.2)	47.6 (1.0)

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

PK = processed kimberlite

Table 9. Total nutrients in processed kimberlite reclamation treatments.

Reclamation Treatment	Carbon (%)	Nitrogen (%)	Calcium (mg L^{-1})	Magnesium (mg L^{-1})	Potassium (mg L^{-1})	Sodium (mg L^{-1})
Orion PK	1.2 (0.1)	0.0* (0.0)	3.6 (0.7)	5.0 (1.9)	19.8 (1.6)	823.8 (56.9)
Orion PK, Agricultural Soil	1.1 (0.0)	0.0* (0.0)*	5.8 (0.3)	4.8 (1.2)	18.0 (1.0)	643.0 (29.8)
Orion PK, Native Sand	0.4 (0.0)*	0.0* (0.0)	5.3 (0.8)	4.5 (0.3)	8.3 (0.6)	443.0 (21.8)
Orion PK, Yard Compost	3.9 (0.7)	0.3 (0.1)	51.0 (9.5)	78.8 (11.3)	183.7 (28.2)	1567.7 (97.0)
Orion PK, Biosolids compost	2.7 (0.1)	0.2 (0.0)*	28.2 (0.3)	36.3 (0.5)	294.0 (6.2)	1116.7 (18.6)
Star PK	0.9 (0.0)*	0.0* (0.0)	12.5 (0.8)	42.7 (2.3)	32.1 (1.6)	591.8 (44.1)
Star PK, Agricultural Soil	1.0 (0.0)	0.1 (0.0)*	71.8 (6.3)	67.6 (3.1)	34.1 (1.0)	562.7 (62.3)
Star PK, Native Sand	0.5 (0.0)*	0.0* (0.0)	36.1 (0.6)	53.9 (1.4)	17.1 (0.5)	605.33 (16.0)
Star PK, Yard Compost	2.6 (0.2)	0.2 (0.0)*	348.7 (35.1)	604.7 (34.8)	334.3 (29.9)	1078.7 (47.1)
Star PK, Biosolids Compost	2.2 (0.2)	0.1 (0.0)*	115.7 (5.2)	176.3 (6.7)	541.7 (35.9)	865.3 (66.0)
Mix PK	1.0 (0.1)	0.0* (0.0)	13.6 (2.5)	3.0 (0.5)	23.2 (1.7)	1254.0 (87.8)
Mix PK, Agricultural Soil	1.0 (0.0)*	0.0* (0.0)*	19.1 (1.9)	2.5 (0.0)	23.3 (0.9)	1256.7 (23.3)
Mix PK, Native Sand	0.4 (0.0)*	0.0* (0.0)	9.6 (0.7)	2.5 (0.0)	15.0 (2.1)	950.0 (66.8)
Mix PK, Yard Compost	3.5 (0.2)	0.3 (0.0)*	78.7 (7.1)	31.0 (3.8)	121.3 (2.7)	2550.0 (85.4)
Mix PK, Biosolids Compost	2.8 (0.1)	0.2 (0.0)*	50.6 (3.9)	24.3 (1.7)	181.7 (16.6)	1090.0 (34.6)

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

PK = processed kimberlite

Table 10. Available nutrients of processed kimberlite reclamation treatments.

Reclamation Treatment	Nitrogen (mg kg^{-1})	Phosphorus (mg kg^{-1})	Potassium (mg kg^{-1})	Sulfur (mg kg^{-1})
Orion PK	6.7 (0.5)	1.0 (0.0)	206.4 (12.2)	121.7 (9.4)
Orion PK, Agricultural Soil	18.7 (0.6)	7.9 (0.4)	159.7 (4.8)	84.7 (7.1)
Orion PK, Native Sand	3.6 (0.2)	5.1 (0.3)	90.0 (5.3)	60.6 (2.1)
Orion PK, Yard Compost	219.7 (32.6)	657.3 (241.3)	844.7 (177.7)	453.3 (47.3)
Orion PK, Biosolids Compost	95.3 (2.5)	61.0 (1.2)	1260.0 (28.5)	150.3 (0.9)
Star PK	1.7 (0.5)	1.0 (0.0)	119.8 (3.1)	93.2 (7.0)
Star PK, Agricultural Soil	14.0 (1.5)	12.3 (3.4)	149.3 (1.8)	84.5 (7.7)
Star PK, Native Sand	2.1 (0.7)	2.0 (0.5)	71.3 (3.4)	76.5 (1.3)
Star PK, Yard Compost	786.7 (336.9)	171.2 (47.0)	477.7 (38.7)	369.7 (19.7)
Star PK, Biosolids Compost	34.0 (4.8)	2.2 (0.2)	1035.0 (70.8)	173.0 (5.3)
Mix PK	55.6 (5.2)	1.2 (0.2)	307.0 (4.8)	202.8 (22.9)
Mix PK, Agricultural Soil	26.4 (1.1)	18.4 (0.8)	229.7 (1.2)	124.0 (8.7)
Mix PK, Native Sand	15.0 (0.2)	4.9 (0.8)	163.7 (6.6)	107.7 (2.0)
Mix PK, Yard Compost	375.0 (29.0)	1004.3 (63.9)	777.3 (42.3)	514.0 (18.2)
Mix PK, Biosolids Compost	92.3 (5.7)	104.3 (1.8)	1013.0 (47.0)	106.0 (2.5)

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

PK = processed kimberlite

Table 11. Available micro nutrients of processed kimberlite reclamation treatments.

Reclamation Treatment	Copper (mg kg^{-1})	Zinc (mg kg^{-1})	Manganese (mg kg^{-1})	Iron (mg kg^{-1})
Orion PK	1.8 (0.1)	1.3 (0.1)	4.3 (0.6)	31.6 (1.8)
Orion PK, Agricultural Soil	1.0 (0.0)*	2.4 (0.3)	3.0 (0.0)*	30.3 (0.7)
Orion PK, Native Sand	0.7 (0.0)*	0.5 (0.0)*	2.5 (0.1)	21.8 (0.4)
Orion PK, Yard Compost	9.4 (2.0)	8.8 (2.4)	16.8 (2.5)	8.8 (2.4)
Orion PK, Biosolids Compost	1.8 (0.0)*	16.7 (2.8)	7.7 (0.0)*	59.4 (1.0)
Star PK	1.3 (0.0)*	0.9 (0.0)*	1.5 (0.1)	33.3 (1.0)
Star PK, Agricultural Soil	0.7 (0.1)	12.9 (5.0)	2.5 (0.1)	27.6 (0.7)
Star PK, Native Sand	0.6 (0.1)	0.5 (0.0)*	1.8 (0.1)	25.9 (1.1)
Star PK, Yard Compost	5.5 (0.5)	6.1 (0.5)	9.6 (0.9)	32.7 (1.2)
Star PK, Biosolids Compost	1.2 (0.1)	7.1 (0.3)	4.4 (0.1)	42.3 (1.0)
Mix PK	1.2 (0.1)	1.1 (0.1)	4.7 (0.2)	9.1 (0.5)
Mix PK, Agricultural Soil	1.0 (0.0)*	1.1 (0.2)	5.1 (0.1)	15.3 (0.2)
Mix PK, Native Sand	0.8 (0.0)*	0.6 (0.0)*	4.3 (0.2)	14.1 (0.0)*
Mix PK, Yard Compost	9.6 (0.4)	13.9 (1.0)	20.7 (0.5)	20.9 (0.6)
Mix PK, Biosolids Compost	1.2 (0.0)*	4.1 (0.1)	8.8 (0.1)	57.5 (2.1)

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

PK = processed kimberlite

Table 12a. Metal concentrations in processed kimberlite reclamation treatments.

Reclamation Treatment	Antimony (mg kg^{-1})	Arsenic (mg kg^{-1})	Barium (mg kg^{-1})	Cadmium (mg kg^{-1})	Chromium (mg kg^{-1})	Cobalt (mg kg^{-1})
Orion PK	0.1 (0.0)*	3.2 (0.6)	211.8 (11.6)	0.0* (0.0)	546.4 (41.6)	76.0 (6.0)
Orion PK, Agricultural Soil	0.1 (0.0)	2.0 (0.1)	110.8 (10.4)	0.0* (0.0)	258.7 (40.3)	29.0 (4.1)
Orion PK, Native Sand	0.1 (0.0)	2.7 (0.1)	112.0 (3.1)	0.0* (0.0)	212.7 (5.4)	26.9 (1.2)
Orion PK, Yard Compost	0.4 (0.1)	1.8 (0.1)	214.7 (2.0)	1.8 (0.1)	386.7 (14.0)	57.7 (4.1)
Orion PK, Biosolids Compost	0.1 (0.0)*	2.2 (0.1)	134.3 (7.4)	4.3 (4.3)	263.3 (18.2)	34.9 (2.5)
Star PK	0.1 (0.0)	2.0 (0.1)	209.6 (7.5)	0.0* (0.0)	398.4 (13.8)	70.9 (1.0)
Star PK, Agricultural Soil	0.1 (0.0)	1.8 (0.1)	113.1 (14.0)	0.0* (0.0)	193.3 (34.1)	37.5 (7.7)
Star PK, Native Sand	0.1 (0.0)	2.5 (0.1)	125.7 (10.5)	0.0* (0.0)	191.7 (24.9)	39.2 (5.1)
Star PK, Yard Compost	0.4 (0.1)	1.7 (0.1)	165.3 (5.8)	0.0* (0.0)	316.3 (6.1)	58.9 (1.7)
Star PK, Biosolids Compost	0.1 (0.0)	2.0 (0.1)	124.3 (7.7)	0.0* (0.0)	238.0 (28.7)	43.1 (5.2)
Mix PK	0.1 (0.0)	0.8 (0.0)*	268.8 (13.8)	0.0 (0.0)	350.8 (26.0)	47.8 (1.3)
Mix PK, Agricultural Soil	0.1 (0.0)	1.3 (0.1)	212.0 (16.8)	0.0* (0.0)	190.7 (7.8)	31.3 (1.5)
Mix PK, Native Sand	0.1 (0.0)	2.2 (0.4)	154.4 (30.6)	0.0* (0.0)	155.1 (36.5)	23.3 (5.4)
Mix PK, Yard Compost	0.3 (0.0)*	1.2 (0.0)*	255.0 (16.5)	0.0* (0.0)	278.0 (52.5)	37.0 (1.7)
Mix PK, Biosolids Compost	0.1 (0.0)	1.7 (0.1)	169.0 (14.0)	0.0* (0.0)	222.3 (52.5)	40.8 (4.1)
CCME Guidelines	-	12	500	1.4	64	40

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

PK = processed kimberlite

Table 12b. Metal and selenium concentrations in processed kimberlite reclamation treatments.

Reclamation Treatment	Copper (mg kg^{-1})	Lead (mg kg^{-1})	Molybdenum (mg kg^{-1})	Selenium (mg kg^{-1})	Silver (mg kg^{-1})	Tin (mg kg^{-1})
Orion PK	59.5 (7.0)	6.9 (0.4)	3.1 (0.7)	0.3 (0.0)	0.5 (0.0)	2.5 (0.0)
Orion PK, Agricultural Soil	22.4 (2.6)	2.5 (0.0)	0.5 (0.0)	0.3 (0.0)	0.5 (0.0)	2.5 (0.0)
Orion PK, Native Sand	20.4 (1.2)	3.5 (1.0)	0.5 (0.0)	0.3 (0.0)	0.5 (0.0)	2.5 (0.0)
Orion PK, Yard Compost	84.0 (13.5)	9.4 (0.9)	1.9 (0.3)	0.5 (0.1)	0.9 (0.4)	3.7 (1.2)
Orion PK, Biosolids Compost	27.1 (1.5)	6.5 (0.3)	0.5 (0.0)	0.3 (0.0)	0.5 (0.0)	2.5 (0.0)
Star PK	42.8 (2.7)	6.9 (0.2)	1.4 (0.2)	0.3 (0.0)	0.5 (0.0)	2.5 (0.0)
Star PK, Agricultural Soil	24.1 (4.2)	4.5 (1.0)	0.5 (0.0)	0.3 (0.0)	0.5 (0.0)	4.7 (2.2)
Star PK, Native Sand	20.3 (2.4)	4.6 (1.0)	0.5 (0.0)	0.3 (0.0)	0.5 (0.0)	2.5 (0.0)
Star PK, Yard Compost	75.8 (11.6)	9.5 (0.7)	1.6 (0.3)	0.5 (0.1)	0.9 (0.2)	2.5 (0.0)
Star PK, Biosolids Compost	24.8 (2.8)	6.7 (0.2)	0.5 (0.0)	0.3 (0.0)	0.5 (0.0)	2.5 (0.0)
Mix PK	28.6 (1.8)	7.9 (0.3)	0.5 (0.0)	0.3 (0.0)	0.5 (0.0)	2.5 (0.0)
Mix PK, Agricultural Soil	23.8 (5.4)	6.4 (0.4)	0.5 (0.0)	0.3 (0.0)	0.5 (0.0)	2.5 (1.0)
Mix PK, Native Sand	15.5 (3.0)	4.6 (1.0)	0.5 (0.0)	0.3 (0.0)	0.5 (0.0)	2.5 (0.0)
Mix PK, Yard Compost	66.4 (3.9)	10.8 (0.3)	1.1 (0.1)	0.6 (0.0)*	0.8 (0.3)	2.5 (0.0)
Mix PK, Biosolids Compost	24.0 (1.9)	6.5 (0.2)	0.5 (0.0)	0.3 (0.0)	0.5 (0.0)	2.5 (0.0)
CCME Guidelines	63	70	-	1	-	-

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

PK = processed kimberlite

Table 12c. Metal concentrations in processed kimberlite reclamation treatments.

Reclamation Treatment	Uranium (mg kg^{-1})	Nickel (mg kg^{-1})	Vanadium (mg kg^{-1})	Zinc (mg kg^{-1})
Orion PK	1.0 (0.0)	986.2 (76.6)	74.8 (7.7)	46.8 (2.5)
Orion PK, Agricultural Soil	1.0 (0.0)	379.7 (58.0)	35.8 (3.8)	36.3 (1.8)
Orion PK, Native Sand	1.0 (0.0)	341.7 (14.1)	30.5 (1.6)	26.3 (0.7)
Orion PK, Yard Compost	2.0 (0.6)	785.7 (54.9)	52.2 (1.2)	90.7 (14.2)
Orion PK, Biosolids Compost	1.0 (0.0)	458.3 (36.9)	37.1 (2.2)	88.7 (11.8)
Star PK	1.0 (0.0)	1346.0 (60.1)	50.0 (1.7)	46.6 (1.3)
Star PK, Agricultural Soil	1.0 (0.0)	605.3 (138.1)	28.1 (3.0)	54.3 (9.3)
Star PK, Native Sand	1.0 (0.0)	606.7 (85.7)	27.4 (1.8)	32.7 (2.0)
Star PK, Yard Compost	2.0 (0.6)	1038.7 (120.9)	39.5 (0.2)	90.3 (10.7)
Star PK, Biosolids Compost	1.0 (0.0)	695.0 (96.5)	31.9 (2.6)	55.0 (2.3)
Mix PK	1.6 (0.4)	670.8 (15.4)	49.2 (0.9)	41.8 (1.0)
Mix PK, Agricultural Soil	1.0 (0.0)	445.0 (18.9)	34.4 (1.1)	60.0 (24.5)
Mix PK, Native Sand	1.0 (0.0)	311.3 (88.2)	26.8 (4.6)	28.0 (3.8)
Mix PK, Yard Compost	2.4 (0.2)	565.3 (39.3)	41.0 (1.5)	131.3 (17.8)
Mix PK, Biosolids Compost	1.4 (0.4)	631.7 (76.1)	32.5 (3.3)	44.0 (1.0)
CCME Guidelines	23	50	130	200

Numbers in brackets are standard errors.

* Trace amounts less than 0.04.

PK = processed kimberlite

Table 13. Seed germination and establishment in Orion processed kimberlite at 12 weeks.

Amendment		*Agropyron trachycaulum*	*Bromus elatior*	*Elymus innovatus*	*Festuca saximontana*	*Hordeum vulgare*	*Koeleria macrantha*
Unamended	Germination	79 (7)	62 (7)	70 (7)	20 (2)	84 (4)	3 (2)
	Establishment	96.9 (6.1)	100.0 (0.0)	65.6 (17.8)	53.3 (16.2)	72.1 (8.2)	20.0 (20.0)
Agricultural Soil	Germination	73 (6)	82 (9)	56 (5)	28 (5)	94 (2)	27 (7)
	Establishment	84.5 (6.9)	97.5 (2.5)	58.9 (9.4)	82.7 (7.5)	77.1 (10.6)	82.7 (12.9)
Native Sand	Germination	84 (3)	72 (7)	74 (4)	25 (9)	98 (2)	45 (7)
	Establishment	100.0 (0.0)	100.0 (0.0)	70.9 (10.0)	53.3 (16.2)	96.0 (2.4)	70.1 (13.1)
Fertilizer	Germination	75 (7)	54 (10)	58 (7)	17 (6)	94 (2)	12 (2)
	Establishment	98.3 (1.7)	100.0 (0.0)	93.8 (3.8)	63.0 (19.2)	70.5 (9.0)	50.0 (22.4)
Yard Compost	Germination	41 (5)	48 (9)	24 (7)	17 (5)	66 (9)	9 (3)
	Establishment	100 (0.0)	100.0 (0.0)	80.0 (20.0)	80.0 (20.0)	100.0 (0.0)	60.0 (24.5)
Biosolids Compost	Germination	81 (3)	62 (11)	52 (4)	33 (6)	82 (6)	24 (2)
	Establishment	100 (0.0)	100.0 (0.0)	96.7 (3.3)	87.1 (9.7)	100.0 (0.0)	73.3 (13.8)

Numbers in brackets are standard errors.

* Trace amounts less than 0.4.

Table 14. Seed germination and establishment in Star processed kimberlite at 12 weeks.

Amendment		*Agropyron trachycaulum*	*Bromus elatior*	*Elymus innovatus*	*Festuca saximontana*	*Hordeum vulgare*	*Koeleria macrantha*
Unamended	Germination	88 (4)	84 (5)	34 (9)	41 (9)	90 (7)	29 (7)
	Establishment	97.0 (1.9)	100.0 (0.0)	77.1 (19.5)	80.5 (7.0)	90.1 (6.1)	79.8 (8.2)
Agricultural Soil	Germination	84 (5)	68 (13)	38 (7)	19 (7)	80 (18)	21 (2)
	Establishment	97.1 (2.9)	98.0 (2.0)	81.7 (14.5)	28.3 (17.4)	91.6 (4.1)	53.3 (22.6)
Native Sand	Germination	87 (2)	76 (7)	44 (7)	35 (7)	92 (5)	40 (6)
	Establishment	100.0 (0.0)	100.0 (0.0)	92.1 (5.1)	75.3 (8.0)	98.0 (2.0)	92.5 (5.0)
Fertilizer	Germination	69 (9)	56 (5)	40 (5)	16 (5)	86 (5)	9 (3)
	Establishment	98.3 (1.7)	100.0 (0.0)	80.0 (20.0)	70.0 (20.0)	100.0 (0.0)	80.0 (20.0)
Yard Compost	Germination	67 (6)	64 (4)	42 (10)	17 (6)	72 (6)	15 (8)
	Establishment	96.2 (2.3)	100.0 (0.0)	79.2 (6.4)	50.0 (21.1)	100.0 (0.0)	42.7 (23.5)
Biosolids Compost	Germination	69 (3)	60 (7)	40 (10)	24 (8)	86 (5)	13 (6)
	Establishment	100.0 (0.0)	100.0 (0.0)	96.7 (3.3)	62.5 (15.8)	100.0 (0.0)	57.3 (20.5)

Numbers in brackets are standard errors.

* Trace amounts less than 0.4.

Table 15. Seed germination and establishment in mixed coarse processed kimberlite at 12 weeks.

Amendment		*Agropyron trachycaulum*	*Bromus elatior*	*Elymus innovatus*	*Festuca saximontana*	*Hordeum vulgare*	*Koeleria macrantha*
Unamended	Germination	77 (5)	64 (5)	62 (12)	17 (3)	84 (10)	15 (6)
	Establishment	100.0 (0.0)	96.7 (3.3)	73.1 (18.7)	20.0 (20.0)	76.0 (11.2)	34.7 (18.3)
Agricultural Soil	Germination	78 (11)	84 (7)	52 (7)	52 (6)	96 (2)	39 (5)
	Establishment	91.7 (8.3)	100.0 (0.0)	45.1 (13.3)	74.1 (8.7)	68.9 (7.3)	69.1 (11.8)
Native Sand	Germination	91 (5)	84 (9)	74 (4)	44 (8)	100 (0)	35 (5)
	Establishment	89.9 (7.1)	98.0 (2.0)	92.5 (7.5)	54.9 (6.4)	80.0 (7.1)	58.3 (5.3)
Fertilizer	Germination	49 (7)	18 (4)	16 (7)	27 (12)	78 (7)	11 (4)
	Establishment	93.3 (2.8)	100.0 (0.0)	20.0 (12.2)	14.0 (11.7)	83.6 (10.1)	40.0 (19.4)
Yard Compost	Germination	69 (5)	46 (12)	38 (8)	15 (4)	72 (4)	7 (5)
	Establishment	98.2 (1.8)	100.0 (0.0)	96.0 (4.0)	73.3 (19.4)	100.0 (0.0)	41.7 (25.0)
Biosolids Compost	Germination	43 (7)	28 (11)	30 (5)	17 (5)	64 (7)	9 (5)
	Establishment	98.0 (2.0)	80.0 (20.0)	88.3 (7.3)	95.0 (5.5)	100.0 (0.0)	35.0 (21.8)

Numbers in brackets are standard errors.

* Trace amounts less than 0.4.

Table 16. Plant response in Orion processed kimberlite at 12 weeks.

Amendment		*Agropyron trachycaulum*	*Bromus elatior*	*Elymus innovatus*	*Festuca saximontana*	*Hordeum vulgare*	*Koeleria macrantha*
Unamended	Density	11 (1)	5 (1)	5 (2)	2 (1)	1 (1)	0* (0)*
	Height (cm)	16 (2)	8 (1)	4 (1)	2 (1)	11 (6)	1 (1)
	Biomass	0.19 (0.05)	0.07 (0.01)	0.02 (0.01)	0.00* (0.00)*	0.33 (0.14)	0.00 (0.00)
Agricultural Soil	Density	9 (1)	4 (1)	3 (1)	3 (1)	2 (1)	3 (1)
	Height (cm)	33 (3)	33 (4)	14 (2)	7 (2)	21 (9)	5 (1)
	Biomass	0.87 (0.14)	0.58 (0.12)	0.10 (0.02)	0.02 (0.00)*	0.98 (0.38)	0.01 (0.01)
Native Sand	Density	13 (0)*	6 (1)	5 (1)	3 (1)	4 (0)*	5 (1)
	Height (cm)	23 (3)	13 (1)	9 (1)	2 (1)	33 (3)	2 (1)
	Biomass	0.48 (0.08)	0.16 (0.03)	0.06 (0.01)	0.00* (0.00)*	0.92 (0.11)	0.01 (0.00)*
Fertilizer	Density	11 (1)	4 (1)	5 (1)	2 (1)	2 (1)	1 (0)*
	Height (cm)	30 (1)	10 (2)	9 (3)	3 (1)	13 (6)	2 (0)*
	Biomass	0.70 (0.11)	0.10 (0.04)	0.06 (0.02)	0.00* (0.00)*	0.45 (0.11)	0.00 (0.00)
Yard Compost	Density	6 (1)	4 (1)	2 (1)	3 (1)	6 (1)	1 (1)
	Height (cm)	32 (4)	56 (5)	28 (7)	8 (3)	44 (1)	5 (2)
	Biomass	1.78 (0.35)	2.02 (0.37)	0.55 (0.22)	0.03 (0.02)	5.62 (0.62)	0.01 (0.00)*
Biosolids Compost	Density	12 (1)	5 (1)	5 (0)*	4 (1)	5 (0)*	3 (1)
	Height (cm)	39 (3)	56 (1)	37 (2)	16 (4)	56 (1)	11 (2)
	Biomass	3.18 (0.52)	2.14 (0.35)	1.32 (0.34)	0.32 (0.14)	5.65 (4.22)	0.06 (0.02)

Numbers in brackets are standard errors.

* Trace amounts less than 0.4.

Table 17. Plant response in Star processed kimberlite at 12 weeks.

Amendment		*Agropyron trachycaulum*	*Bromus elatior*	*Elymus innovatus*	*Festuca saximontana*	*Hordeum vulgare*	*Koeleria macrantha*
Unamended	Density	13 (1)	6 (1)	3 (1)	5 (1)	4 (1)	4 (1)
	Height (cm)	20 (3)	13 (1)	11 (2)	3 (1)	29 (1)	2 (0)*
	Biomass	0.38 (0.14)	0.13 (0.02)	0.02 (0.01)	0.01 (0.00)*	0.80 (0.12)	0.00* (0.00)*
Agricultural Soil	Density	12 (1)	4 (1)	3 (1)	1 (1)	3 (1)	2 (1)
	Height (cm)	31 (2)	42 (3)	21 (3)	7 (4)	36 (3)	4 (2)
	Biomass	1.06 (0.11)	0.68 (0.12)	0.12 (0.03)	0.08 (0.07)	1.22 (0.16)	0.00* (0.00)*
Native Sand	Density	13 (0)*	5 (0)*	4 (1)	4 (1)	5 (0)*	6 (1)
	Height (cm)	27 (2)	24 (2)	24 (2)	7 (3)	38 (2)	8 (1)
	Biomass	0.67 (0.12)	0.38 (0.03)	0.21 (0.04)	0.04 (0.02)	1.52 (0.28)	0.04 (0.01)
Fertilizer	Density	10 (1)	5 (1)	3 (1)	2 (1)	5 (0)*	1 (0)*
	Height (cm)	33 (3)	34 (3)	20 (3)	5 (2)	43 (2)	3 (1)
	Biomass	0.92 (0.16)	0.53 (0.17)	0.18 (0.07)	0.02 (0.01)	2.81 (0.66)	0.00* (0.00)*
Yard Compost	Density	10 (1)	6 (1)	3 (1)	2 (1)	6 (0)*	1 (0)*
	Height (cm)	35 (4)	62 (3)	34 (3)	7 (4)	49 (4)	3 (1)
	Biomass	3.56 (0.83)	3.81 (0.15)	1.34 (0.64)	0.09 (0.07)	6.42 (0.69)	0.00* (0.00)
Biosolids Compost	Density	10 (1)	6 (1)	4 (1)	2 (1)	5 (0)*	1 (0)*
	Height (cm)	38 (1)	48 (2)	36 (4)	11 (4)	53 (2)	3 (1)
	Biomass	2.42 (0.40)	1.56 (0.15)	0.99 (0.35)	0.03 (0.02)	4.91 (0.80)	0.00* (0.00)*

Numbers in brackets are standard errors.

* Trace amounts less than 0.4.

Table 18. Plant response in mixed coarse processed kimberlite at 12 weeks.

Amendment		*Agropyron trachycaulum*	*Bromus elatior*	*Elymus innovatus*	*Festuca saximontana*	*Hordeum vulgare*	*Koeleria macrantha*
Unamended	Density	12 (1)	4 (1)	5 (2)	0* (0)*	2 (1)	1 (0)*
	Height (cm)	22 (6)	9.0 (1)	3 (1)	1 (1)	10 (6)	1 (1)
	Biomass	0.72 (0.45)	0.05 (0.01)	0.01 (0.00)*	0.00 (0.00)	0.40 (0.12)	0.00* (0.00)
Agricultural Soil	Density	11 (2)	6 (1)	2 (1)	6 (1)	2 (1)	4 (1)
	Height (cm)	34 (3)	21 (3)	12 (3)	6 (4)	19 (5)	6 (1)
	Biomass	1.78 (0.13)	0.36 (0.07)	0.06 (0.02)	0.07 (0.04)	0.44 (0.05)	0.03 (0.00)*
Native Sand	Density	12 (1)	5 (0)*	7 (1)	4 (1)	3 (1)	3 (1)
	Height (cm)	27 (2)	12 (1)	9 (0)*	7 (2)	30 (1)	2 (1)
	Biomass	0.87 (0.08)	0.17 (0.01)	0.07 (0.01)	0.02 (0.00)*	0.88 (0.06)	0.00* (0.00)*
Fertilizer	Density	7 (1)	1 (0)*	0* (0)*	1 (1)	3 (2)	1 (0)*
	Height (cm)	19 (5)	16 (3)	18 (2)	1 (1)	16 (7)	2 (1)
	Biomass	0.28 (0.15)	0.05 (0.04)	0.00* (0.00)*	0.00* (0.00)*	0.46 (0.08)	0.00 (0.00)
Yard Compost	Density	10 (1)	4 (1)	4 (1)	2 (1)	6 (1)	1 (1)
	Height (cm)	42 (2)	53 (7)	25 (5)	6 (2)	43 (4)	2 (2)
	Biomass	3.36 (0.68)	1.80 (0.63)	0.41 (0.18)	0.01 (0.00)*	7.77 (0.89)	0.00* (0.00)*
Biosolids Compost	Density	6 (1)	3 (1)	3 (1)	2 (1)	5 (1)	1 (1)
	Height (cm)	34 (5)	40 (11)	40 (5)	16 (4)	50 (3)	2 (1)
	Biomass	1.94 (0.52)	1.06 (0.52)	0.73 (0.28)	0.14 (0.06)	4.50 (0.39)	0.00* (0.00)

Numbers in brackets are standard errors.

* Trace amounts less than 0.4.

Table 19. Overall plant response to processed kimberlite reclamation treatments.

	Orion	Star	Mixed	Mean
Germination				
Unamended	53	61	53	56
Agricultural Soil	60	52	67	60
Native Sand	66	62	71	66
Fertilizer	52	46	33	44
Yard Compost	34	46	41	40
Biosolids Compost	56	49	32	46
Establishment				
Unamended	68	87	67	74
Agricultural Soil	81	75	75	77
Native Sand	82	93	79	85
Fertilizer	79	88	58	75
Yard Compost	87	78	85	83
Biosolids Compost	93	86	83	87
Biomass				
Unamended	0.1017	0.2233	0.1967	0.1739
Agricultural Soil	0.4267	0.5367	0.4567	0.4734
Native Sand	0.2717	0.4767	0.3350	0.6945
Fertilizer	0.2183	0.7433	0.1317	0.3644
Yard Compost	1.6683	2.5367	2.2250	2.1433
Biosoilds Compost	2.1117	1.6517	1.3950	1.7195

Table 19. Comparisons of processed kimberlite reclamation treatments.

Treatment	Recommend for Field Research	Justification	Operational Applicability	Potential Limitations
Orion Fine PK	Yes	• Adequate establishment and growth of most species. • *Elymus innovatus* performed best compared to other unamended treatments.	• Single material, easy to apply.	• High SAR, Cr and Co and low N and P may inhibit plant growth in longer term.
Star Fine PK	Yes	• Lowest pH, EC and SAR. • Texture most ideal for plant growth. • Unamended provided best results for most species.	• Single material, easy to apply.	• High Cr and Co and low N and P may inhibit plant growth in longer term.
Orion Star Mix Coarse PK	Yes	• Available N high. • Adequate establishment and growth of most species. • *Agropyron trachycaulum* performed best compared to other unamended treatments.	• Homogeneous mix more difficult to create and apply than a single material.	• High SAR, Cr and low P may inhibit plant growth in longer term. • Coarse texture may reduce nutrient and water retention.
Agricultural Soil	Yes	• Enhanced establishment of some species. • Increased biomass production though not as much as composts.	• Locally available. Stability of source unknown.	
Native Sand	Yes	• Enhances germination and final plant densities. • *Koeleria macrantha* performed best in these treatments. • Biomass of *Elymus innovatus* and *Festuca saximontana* increased when added to Star PK.	• Locally available. Stability of source unknown.	• Reduced available N.
	Yes / No	• No significant increase in plant response compared to unamended PK. • Detrimental to *Agropyron trachycaulum*, *Bromus elatior*, *Elymus innovatus* when added to Mix PK. • Increased N and P may assist plant growth most in the longer term.	• Readily available and easy to apply to large areas. • Benefits in conjunction with other amendments should be tested.	• Native and agronomic species may have different nutrient requirements. • Nutrients may be leached without additional organic amendments.

Yard Compost	Yes	• Increases total C, total and available N, available P. • Increases plant height and aboveground biomass.	• Locally available. • Variation in feed stocks may alter chemical properties.	• Reduced germination but produced larger plants. • Excessive P and S may be detrimental to plant growth. • Increased Mn, Pb, Cu, and EC.
Biosolids Compost	Yes	• Increases total C, total and available N, available K. • Increases plant height and aboveground biomass	• Locally available. • Government regulations in place which may limit its use on agricultural lands.	• Reduced germination but produced larger plants. • Excessive K may be detrimental to plant growth • Increased Mn and EC
Native Forages	Yes	• Consistently good germination, establishment and production. • *Hordeum vulgare* has rapid growth and high biomass production.	• Seed available and inexpensive.	
Native Grasses	Yes	• Good germination, establishment and production. • Specific results species dependent. • Native species may be more tolerant of poor soil conditions than agronomics.	• Seed available.	• Germination rates variable; need to sow accordingly.
Native Trees	No	• Seedlings did not survive more than two weeks in any treatment	• Trees required depending on end land use. • Investigate other reclamation substrates and species. • Seed not readily available.	