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Advance Fast Water Spill Response Tactics

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ABSTRACT 300063:

Alaska rivers and streams present many distinct challenges for spill response due to the remoteness of the environment of the 800 miles of Trans Alaska Pipeline traverses through Alaska. The Glacial and non Glacial streams and rivers seasonally produce current velocities that vary from 2 ft/s to 12 ft/s for operating conditions to respond to the event of a spill that may potentially enter them.

Alyeska Pipeline Service Company has 5 different programs that the Emergency Preparedness Compliance Team actively employs. These Programs have contributed to developing innovative advanced fast water booming containment and recovery tactical responses to potential oil spill scenarios. These programs are the Pipeline C-Plan Equipment & PM Committee, Pipeline Training Academy, Exercise and Lessons Learned, Vessel Operating Committee, and LPS Safety Programs that affect Oil Spill Response. These programs have a strong focus on safety.

The development of faster boom has increased the capability of booming extremely fast water that was not achievable in the past. The further development of midstream anchoring systems and shoreline anchor systems has advanced the capabilities of booming rivers that were previously not achievable. There are difficult challenges of fast water river systems that do not present slow or back water eddies for containment and recovery. They have now become achievable using partial deployment of portable light weight dams across a small segment of the river profile to produce these opportunities for recovery. Helicopter slinging operations using the Harbour Buster System to remote rivers of Alaska have also proven to be effective and tested for response capabilities.

The techniques used are equally applicable to all regions of the world and have been presented to a network of OSRO’s. The presentation will present the development of empirical data gathered from different river velocities and conditions. Using this research data will help predict and calculate boom requirements in each unique condition for Operations and Task Forces in tactical response. Profiling river hydrology is essential to the success of containment and recovery. The profiling assessment will identify key elements for operational and tactic decisions in choosing the optimal location for making diversion and containment boom sets for recover efforts for spill response.

INTRODUCTION:

The most challenging task of booming rivers, especially fast rivers over 4-5 ft/second current is the ability to select the most suitable area of river to set your boom to divert and collect oil. The basic principle of booming rivers is to drive the oil on the surface of the water using diversion boom from faster water to slower water to collect the oil into your apex of your containment section of the boom set. The boom skirt creates extremely strong forces proportional to the angle the boom is configured toward the shoreline. The more aggressive the angle the more force encountered. The strategy is to drive the oil at as sharp of an angle as possible in fast water without causing entrainment of oil under the boom skirt.

The advantage a river has over open water oil spill responses is the current creates a very effective encounter rate to collect oil. The disadvantage is getting a head of the leading edge of oil downstream and effective diverting the oil into an area of slow or calm water to collect the oil on the water surface.

The rivers hydrology creates varying current velocities as it travels downstream. The outside turns of a river create very high velocities compared to the inside velocities which tend to be much slower. In long linear sections of rivers the velocities are more uniform on opposing banks of the river. These areas give a task force booming a river a higher potential of success in driving oil to the shoreline. The center of the river in long linear sections of river will tend to have the highest velocity. The best scenario for booming large sections of river is using a long linear section of river that is naturally dammed at the end of the linear section when river starts to bend either left or right. Each river is unique and so are the sections of a river. The strategy is to divert the oil over to the shoreline to the side of the river with the slowest current or a back eddy that is created as the river starts to bend to collect oil in the apex of your boom set.

The most obvious sections of river to avoid is where the river drops in elevation creating strong river current velocities and rapids that very difficult to almost impossible to boom and divert oil on the surface. An over flight of the river by aircraft is an excellent method in determining areas of opportunity for setting up potential task forces for diversion boom sets and recovery.

The tendency of most responders is to use as short number of sections of boom connected together as possible. Trying to force boom over to the shoreline causes entrainment of oil under the skirt as it will cause the boom to lay over at extreme angles with the water. This will also cause bellies in the boom sections where tag lines are attached at alternating location at connector plates on the boom to divert the boom to the shoreline. Through extensive testing of different sizes of boom floatation and skirt lengths came the development of an effective fast water boom for collecting oil. The most suitable boom for fast water that is both effective in driving oil on the surface of the water and not causing entrainment is a boom with 6 inches floatation and 4 inches of skirt. The 6 inch floatation chamber pillow gives the boom of enough buoyancy to prevent splash over of oil on the boom. The closed cell foam floatation boom pillows are preferable over air inflation boom since they will not sink the boom even with a small hole in the floatation chamber. The 4 inches of skirt allows you to collect oil off the surface of the fast moving current without creating extreme forces on the boom that will not allow you to have an effective angle for your boom set in diverting oil to the shoreline that a 6 inch or longer skirt will create. The 6” X 4” floatation to skirt length of boom has been tested in many of exercise deployments using natural products such as large sacks of spruce cone scales spread over the river surface of the water to simulate oil. Invariably most if not all the scales were diverted and collected in the boom apex for recovery when deployed properly. The oil stimulant allowed us to find places of entrainment if too sharp of angle of diversion was used or if the shoreline was not sealed off properly in the apex of containment boom collection site. Next 8 inch buoyancy by 8 inch skirt boom is connected into the final sections down stream in the boom set to create a deeper skirted boom for containment of the collected oil.. The 8” X 8” boom is deployed along the shoreline of the river where the current speed is either very slow or almost nonexistent due to a back eddy.

Tag lines

Tag lines are attached at alternating boom connection plates on a diversion boom sets to assist in pulling segments of boom in fast water to create the force necessary to cause a deflection with the boom. The taglines are held by task force members as the boom is deployed by a boom vane or trolley system. Systematically starting on the upstream tag line, the first couple of sections of boom should be pulled toward shoreline at a 45 degree angle or 60 degree if the current is approaching 5 ft/sec downstream until the maximum amount of deflection is achieved without causing entrainment of oil under the skirt of boom. The next following tag line 2 sections down on the boom set downstream is pulled in until the all the tag lines in succession have been pulled the boom over into a deflection mode. The reason for the 45 to 60 degree angle of the tag line is to eliminate the belly in the boom created if you were to pull perpendicular which can lead to entrainment of oil at that connector plate.

Attaching a tag line 2 to 3 boom sections up on the outside of the boom set connector plate from the tail end of the boom set is a effective method in optimizing deflection of the boom set. The tag line is pulled taut down stream from outside of the boom to shoreline attached to a anchor plate or duckbill anchor. A rope come along can be used to tighten up this anchor tangent to the boom deflection angle to shoreline. This helps optimize the amount boom needed and keeps your boom set nice and straight. This method works equally well in very slow current streams and rivers where there is almost no current at all. The slow current rivers tend to cause the boom to wander and make the deflection of oil not very efficient. This tightening up of the boom from the tag line will create a prefect straighten boom set in slow currents. In fast currents the remaining to 2 to 3 sections of boom can be brought around to shoreline to create a very relaxed apex in the boom with out the high tension being exerted on the up river sections of boom in the diversion set.

Megasecur Dams Creating an Artificial Collection Site

The significant challenge of booming rivers and streams for collection of oil is finding shoreline areas with slow current for collection sites for the oil. The site needs to be tangent to a long stretch of linear section of river to deploy the diversion boom into the collection site. With lack of collection sites on rivers and stream new techniques have been developed using a Megasecur Dam deployed perpendicular from the shoreline to create artificial side dams on the rivers. This will create low velocity current along shorelines to collect oil from backing up water on partial segments of the river. If the stream is small enough, under 40 feet bank to bank, the entire stream and can be backed up to create a slow current for collection. The megasecur dams or equivalent type will not work very effective on partial river deployments if there is a lack of current velocity or no elevation drop in the river. One of these parameters is need for the dam to create a slow quite area along the bank of the river.

Anchoring Systems for Booming Rivers and Streams

Anchor applications can be split up into 2 categories for rivers; midstream or shoreline anchor systems. Boom anchoring systems need to have the potential to hold forces of 1,000 lbs of force to as much as 3,000 lbs of hydraulic force applied to them by the mooring line that has several hundred feet of diversion boom attached to the anchor.

Shoreline Anchors

In many areas large trees can be used as shoreline anchors. But many areas may not have trees available or the trees are too far from the shoreline. In areas in Northern Alaska and Northern Canada there are no trees that grow that far north in areas that have potential for oil spills. Danforth or similar type anchors and Duck bills anchor system will hold small forces from the boom set, but will fail under conditions when 1000 lbs or more force is applied to such an anchoring system. Anchor plates systems have been developed where partially round aluminum plates with 10 each 1 1/2” holes even spaced are drilled into the plates with a 5/8 shackle attached to the end of the plate. 3 foot ¾ inch steel stakes are driven into the ground through these holes in the plate. The side by side holes on the plates steel stakes are crossed to lock the plate from moving and also create a larger subsurface anchoring system. (See picture below of anchor plate system.) Where rivers exceeding 5 ft/s velocities 2 anchor plates are connected to ensure the anchor system does not fail. To further secure the anchoring plate a duckbill anchor is connected to the front shackle of the anchor plate and drove into the ground until the cable attached to the duckbill is taut. This anchor system creates an extreme secure anchor point that works very well in difficult areas to anchor such as muddy or glacial silt shorelines and small or large pebbles shorelines. Safety in working near leading anchor lines attached to the boom is essential since snap back from the line is always a high potential. Job Hazard Analysis should be completed before deploying boom anchor systems to ensure the safety of the responder. These written safety analysis and procedures is a key tool to be used during your on site safety briefings pre-deployment of a task force assignment.

Midstream Anchor Systems

Use of traditional anchor systems such as danforth or bruce anchors works fairly well in low velocity currents and small sections of boom. For higher velocity currents of 2.5 ft/second or better with several hundred feet of diversion boom these anchoring systems will begin to fail. This is particularly true with rivers with rocky bottoms. There are 2 popular midstream anchoring systems that have been exclusively used for response in Alaskan rivers and streams that have proven to be very successful. They are shallow water boom vanes and trolley lines.

Boom vanes

Shallow water boom vanes moored with only one line from the shoreline using anchor plates or large tree can create a midstream anchor for the attached leading edge of diversion boom set to divert the oil to the shoreline. No boats are required to deploy the boom vane and boom from shore where river currents may be too dangerous to navigate a vessel. Boom vanes may also be attached to the tail end of boom set and the leading mooring line of the boom set attached to the same side of the river upstream. The boom vane is deployed off the shoreline from the downstream tail end of the boom and deflects oil away from the shoreline to the other side of the river.

Boom vanes mooring anchoring systems should not be deployed on high banks above river especially in high currents. This tends to cause the boom vane to porpoise 2 to 3 feet in and out of the water causing the boom to surge back and forth from shoreline.

In extremely shallow rivers with 4-5 ft/sec or higher velocities an extreme shallow water boom vane has been developed that can perform in water depths down to 18 inches in depth. The shallow water boom vane requires 24 inches in depth and runs into problems in shallow silty rivers of Alaska that do not have deep channels. This shallow version allows this technology to be used in streams that previously were too shallow for 24 inch model.

Boom Vane deployment Salcha River June, 2013

Trolley System

Trolley lines are used by securing a trolley line perpendicular to the river on each shoreline using anchor plates or multiple duckbill anchors on each side of the river. A rope come along is used to tighten the trolley so that it is tight on the side the boom is to be deployed. A pulley is attached to the trolley line with 3 lines attached to the pulley. An outer tag line is attached to the pull the boom across from the opposite shoreline to the desired section river you wish to boom. The middle line is the short mooring line attached to the diversion boom. The third line is the retrieval line that allows the boom to be retrieved or adjust back to the side of the river the boom was deployed from. This system allows you to adjust the boom set on the trolley line to where it works most effectively with the amount of boom deployed on one set. The disadvantage of this system is it tends to impede navigation on rivers and on large rivers over 250 feet across bank to bank it becomes too difficult to deploy.

Large Release Spill to Fast water Rivers (Nofi Harbour Buster System)

The previously mentioned 6” X 4” diversion boom works very well with 8” X 8” containment boom attached. In large spills dozens numerous sets would be deployed downstream to recover a spill to a river for collection of oil.

New technology has allowed the industry in Alaska to add another tool to recover oil in fast water oil spill response. Nofi Harbour Buster system, when applied to river response allows us to deploy a collection system that can handle a large release of oil downstream. In Alaska where remote areas of river that could potentially a spill can occur the Harbour Buster System and has been sling loaded and deployed by use of 407 Bell helicopters to remote locations on Alaskan rivers. This has proven to be a quite effective tool to have in a response arsenal through testing in the Alyeska Pipeline Service Company Exercise program. The Harbour Buster can operate in 3-4 ft/sec currents and provides an excellent large capacity in its apex to recover oil where conventional boom would have entrainment. Where road access to the river exists the system can be deployed by the boom reel the Harbour Buster is stored on making it an easier deployment method. To measure river current velocities with a flow meter the Harbour Buster was effectively tested in 2013 on the Tanana River at currents of 4 ft/sec, the Yukon River Bridge at current velocities of 3.5 ft/sec and on the Gulkana River in slower waters of 2.5 ft/sec. The system was also tested earlier on the Salcha River in 2010 but current velocities were not accurately recorded.

The Nofi Harbour Buster System is most effective when deployed using a shallow water boom vane attached to the outboard side leg of the boom vane to deploy the entire system into the river. The inboard leg of the boom is secured to the shoreline. The Harbour Buster System exerts extreme forces on the mooring lines of the boom vane and also in the inboard mooring line of the boom. 3 anchor plates in succession are used on the outboard side for the boom vane and 2 anchor plates on the inboard side to handle the forces generated. The retrieval line on the Harbour Buster Apex is secured with 2 anchor plates for retrieving the boom and is a fail safe in case the other anchor plates were to fail.

Salcha River Harbour Buster deployment by aerial slinging June, 2010


N637AL

Yukon River 06/23/2013

Gulkana River 07/25/2013

Assessing Booming Requirements for Rivers

Several tools can be very effective in lining out a river for deploying a boom set. Use of a quality stream current flow meter can determine an accurate measurement of the velocity of the river. Usually crude methods of using a stick and timing a distance is not as accurate a tool. Through experience in booming rivers, task force members will become more efficient at using the correct amount of boom need to boom a river. From experience most task force teams fall short in amount of boom need and tend to keep adding boom. Having an accurate quantitative velocity will assist in determining the amount of boom needed.

The second effective tool is a range finder is use to determine the shoreline to shoreline distance across the river to be boomed. It also allows a Task Force Leader to determine how much shoreline he potential has available in the linear distance on his side of the river to deploy the amount on boom. If eddy exists at the end of the stretch of shoreline a distance can be achieved looking upstream to where the leading edge of the boom is to start in the section of bank to be used. Now he can order through staging the amount of boom needed for this section of river. Furthermore, where a boom vane is used a range finder can be used to determine the distance up from the leading edge of the boom and boom vane to set the anchor plate for the boom vane.

Accuracy in Predicting Boom Requirements

With the use of flow meter and a range finder empirical data has been record from 3 different deployments of fast water boom on rivers in Alaska in 2013. This has allowed data to be plotted on a graph for the different deployment using the fixed parameter in using 6 inch flotation boom with a 4 inch skirt for deflection boom. Using different size of boom would change the results of the test. An average velocity of 8 recordings of river velocity from the shoreline in intervals out to the leading edge of the boom deflection was recorded. The average velocity was used from the data. The second parameter the distance from the shoreline perpendicular to the leading edge of the boom deflection of the river was recorded using the range finder. The third parameter was the amount of boom it took to deflect this section of river. The ratio of the perpendicular distance divide by the boom length was converted to the ratio for every hundred feet of boom. This was plotted on the vertical axis of the graph for the 3 deployments. On the horizontal axis the graph the rivers velocity was plotted on the graph to the point of intersection of ratio of every hundred feet of boom required for that deployment. The results drawing a line through 3 points for each deployment provided almost perfect linear line. Using this graph from the slope of the line on the graph can help determine the amount of boom required for the known river velocity and the perpendicular distance you plan to deploy boom across with good accuracy.

The challenge for most responder is determining resource requirements for boom needed to boom off a section of river. I have experienced varying results but the final outcome is that not enough boom is used in most situations. Use of the range finder and flow meter has produced very good results in recent deployments in determining the correct amount resources required to boom a section of river. Understanding the different river and streams in your contingency area for response and the changing environment conditions seasonally is essential in the type of equipment and response that will be required. Changes from break up to freeze up and high to low water levels will dramatically determine which tactics is used.

Safety of the Response

Safety of the response is critical in final outcome of an oil spill incident. Proper training and a strong safety culture in an organization is important to successfully responding. Having developed pre job hazard analysis for each type of tactics and standard operating procedures is essential to keeping your task forces safe during a response. Conducting task force site safety meetings prior to the deployment will identify changing environmental conditions. When using vessels in a response having procedures in place for a documented float plan, pre-inspections of vessels and good communication plan will greatly improve the safety of your response. Lessons learned through an exercise program and responses will help assist greatly in identify future safety issues that could surface during a response.

CONCLUSION:

Response to an oil spill on rivers and streams has many challenges. Each response and scenario has its on unique characteristics. The different tactics and methods presented will work very effective in one environment but may not in changing circumstances. Each should be thought as a tool in your arsenal of response equipment and tactics. Through tactical assessment and experience in working fast water rivers the correct tool in your arsenal of equipment assist in responding to the actual event. The challenge will always be there in the ability to quickly deploy with the correct amount of resources in a ever changing river environment.