EXECUTIVE SUMMARY

This project is part of a contract with Petroleum Technology Alliance Canada (PTAC). PTAC has engaged InnoTech to test three alternate products which are believed to have superior properties compared to oilwell cement for the purposes of certain well remediation applications and casing plugging. This report is for Phase 1 testing of a resin provided by Challenger Technical Services Ltd. (Challenger). The resin is in development and has not undergone field trials. Challenger intends to use this resin for well remediation in applications behind well casing.

The objective of using a resin in well remediation and abandonment procedures is to reduce costs and to safely improve outcomes while providing permanent barriers for hydraulic isolation in wellbores. With specific applications of this resin, the inventory of leaking wells and inactive wells is expected to be reduced.

An overall testing and assessment procedure developed by InnoTech, in communication with the AER, is designed to support successful field trials with minimal risk of adverse effects or failure over the life of the well, including post decommissioning / abandonment. Acquiring regulatory acceptance for wellbore applications of the resin is critical to achieve the stated purposes of the resin.

A toxicology assessment, a risk assessment and a mitigation strategy based on existing Safety Data Sheets (SDS) was completed including potential risks to ground water. The resin was found to be low to medium risk overall provided all appropriate practices are applied. The recommended mitigation procedures are included in this report and are intended for inclusion into the Challenger standard operating procedures (SOP).

The shrinkage of the resin was calculated at 2.87 % when the resin was curing under 7 MPa pressure in 114.3 mm OD casing. No radial shrinkage was observed on the circumference of small quantities of resin set in 200 ml glass containers or in the 13.6 mm annulus of a dry steel casing stub with an aluminum cylinder placed as a central spacer.

Radial shrinkage was observed when the resin was cured in an empty and dry 114.3 mm OD casing stub. The resin in this casing stub axially expanded out the top of the casing stub when curing at room temperature and pressure. Radial shrinkage was also observed in the table-top resin samples cured in large glass containers and there was evidence of voids in the resin. When placed and cured under pressure in a wellbore, any gas filled voids are expected to be significantly smaller due to gas compression.

Adhesion–shear testing was conducted on resin plugs set in a short pieces of steel casing by using a precision press with a recording instrument. The force required to break the adhesion of a resin sample set inside a casing stub was divided by the inside surface area of the casing stub. Two samples with an internal aluminum centralizer core were tested and two samples with only resin in the casing stub were tested. The lowest shear adhesion was 11.1 MPa for a sample with the centralizer and 0.82 MPa for a resin sample with no centralizer.

Resin was placed in 114.3 mm OD (84.3 mm ID) water wet steel casing and seven 76 mm OD cementing wiper plugs were pushed into the resin. The wiper plugs were intended to be tested as central spacers in the casing. and the plugs totaled 86 cm in length. The casing contained resin above and below the spacers. The casing was pressured to 7 MPa using water and the resin allowed to cure.

After the resin was fully cured in the casing, a differential pressure test was conducted at 7 MPa for 7 days. Water was used as a pressure medium and precision instrumentation recorded the pressure, the pump rate and time. After the resin was cured, an average stabilized leak rate of 1 ml/ hr (0.024 liters per day) was measured. This leak rate would not be detectable in a wellbore pressure test.

Endurance testing of the resin was conducted using a procedure simulating a highly corrosive reservoir condition where an extraordinary rate of uncemented casing failures is known to occur in wellbores. After 194 days of endurance testing, it was evident that the resin degrades less significantly than the class G cement sample and the J55 steel sample. During the endurance testing, the cement sample properties changed over time and the steel sample exhibited a slow and consistent mass loss. This resin did not show any signs of adverse effects and gained 0.6% of its original mass.

The resin was set in motor oil, in water, in canola oil and in a paraffin lined container. No negative effects were observed while the resin was curing in motor oil. Some foaming was observed when the resin was set in water. The resin did not fully cure when it was set in canola oil. The resin is exothermic when setting but the volume and maximum temperature of the sample was not hot enough to fully melt the paraffin lining the glass container. There was visual evidence of a few spots where the paraffin melted. This information may be used when planning further testing on the resin.

It was determined that the resin can be used safely and is not a material risk to ground water when deployed outside of casing, provided all appropriate mitigation procedures are followed.

The resin provided a seal when cured in a short dry casing stub with an aluminum cylinder placed in the middle, but a very low leak rate occurred when the resin was cured in water wet casing with wiper plugs placed as central spacers. Further testing is recommended to investigate these differences and Challenger has work underway to assess this very low leak rate.

The resin appears to be suitable for sealing smaller flow pathways such as annular areas between casing strings or between casing and formation. It is also likely effective for sealing fractures, channels, and worm holes in pre-existing wellbore cement. Further testing that is specific to these conditions is recommended.

The test results indicate that the cured resin has superior properties to oilwell cement in specific applications as a wellbore sealing material.