Microseeps, Inc.

Potential Applications for the Use of CSIA

1) **Apparent cis-DCE stall: Is the cis-DCE degrading, or dormant?** The concentrations may not change, but if there is degradation the isotopic composition will continue to fractionate so the CSIA data will change. . This applies to chlorinated solvents only, and requires only CSIA of carbon.

2) **DNAPL: Is there progress?** The source is not simply the floating product, but all the stored mass in the aquifer – DNAPL stored in soil that wasn't excavated. This acts as a seemingly unlimited source of PCE and or TCE, so even if it is degrading, the dissolved concentrations won't go down. Since ethene is not conserved, monitoring a build-up in ethene is unreliable. The concentrations may not change, but if there is degradation the CSIA information does, and that CSIA information can prove that there are effective degradation mechanisms. This is particular to chlorinated solvents and requires only CSIA of carbon.

3) **Pump and treat shutoff: Is there degradation occurring?** One of the big worries is whether biodegradation will establish itself rapidly enough to be protective immediately, or will there be a fugitive plume escaping between the shut-off of the pump and treat and the start-up of biodegradation. CSIA can tell if there is already bio-degradation occurring, and while a lot will change when the pump and treat stops, having pre-existing biodegradation can shorten the time until biodegradation alone can be protective. This applies to all contaminants, and would best be done with just CSIA of carbon.

4) **Biodegradation of MTBE: Is it occurring?** But for TBA, which is often a co-contaminant so it is of little use, there are no daughter products for MTBE biodegradation and its degradation can be hard to document. In most situations the BTEX in gasoline drives gasoline releases into anaerobic metabolism and the MTBE is left behind in an environment conducive only to anaerobic bacteria. In that situation CSIA of carbon only is often best. That scenario is well documented and there are many existing case studies for it. In some cases (especially those of seepage velocity greater than 1 foot per day) aerobic biodegradation of MTBE is possible and it may be necessary to do CSIA of hydrogen as well. While the science here is excellent and there have been a few examples of it, the utility of the hydrogen analysis for this application is not yet fully established.

5) **ISCO: Altered hydrogeology or successful degradation?** CSIA proves that the concentration didn't just go down because the concentration moved (it may have been pushed out of the way or the hydrogeology may have been otherwise affected) but that the concentration went down because contaminant was destroyed. There are a lot of documented cases of this for chlorinated solvents with CSIA of carbon. There are fewer

documented cases, but there is still very good and readily applicable research documenting MTBE ISCO degradation using CSIA of hydrogen.

6) **Abiotic: How does one document this elusive mechanism?** There are many chlorinated solvent plumes that are going away, but the site managers can't get closure because they can't prove a mechanism. CSIA may not discern abiotic versus biotic, but it will differentiate between "lost" contaminant and degraded contaminant. For many contaminants the case studies already exist and for most of the others, they are on their way. Currently this has been applied to chlorinated solvents and requires only CSIA of carbon.

7) **ISCR iron wall - ZVI – nano-scale iron – other reducing mixtures: Where did it go?** The reasons for doing it are the same as those given for ISCO above. However, because this is a reduction it only applies to chlorinated solvents, and there you'd only look at CSIA of carbon.

8) **LTM: How can CSIA be used to reduce costs?** CSIA can be used to further constrain a site model to PROVE that the remedy is well known or CSIA can be used as another line of evidence (produced by DIRECT analysis of the contaminants!) supporting the conceptual site model that led to a biodegradation remedy choice. Either can be used as a very strong reason to reduce the frequency of long term monitoring (LTM) events and LTM costs. This can be done for chlorinated solvents (strictly carbon only), MTBE (carbon only in most cases) or benzene (hydrogen only).

9) **Aerobic cis-DCE and VC: How do we prove progress without daughter or end products?** It is possible to aerobically degrade these contaminants. There are many good case studies of this applied to vinyl chloride, and it is now possible to obtain cultures which can aerobically degrade cis-DCE. In aerobic biodegradation of these compounds there are no stable daughter products, so it is a difficult remedy to document. You need to prove that the contaminant wasn't simply moved or that the hydrology wasn't simply altered, but that the contaminant was degraded. CSIA is ideal for this. This is only for chlorinated ethenes and requires only CSIA of carbon.

10) **Co-metabolic degradation of chlorinated ethenes: What supports the concentration declines?** While remediation via co-metabolism is currently rare, it is an important remediation mechanism and as people become more concerned about the carbon used to make a plume reducing and about secondary water quality issues remediation through co-metabolism is growing in popularity. As of yet there are no documented case studies of co-metabolic remediation and CSIA, but several practitioners and researchers are working on it. This is only for chlorinated ethenes and requires only CSIA of carbon.

It is important to remember that CSIA is not a "silver bullet". Each of these applications is best implemented when it is accompanied by a good set of standard geochemistry analyses. measurements of the concentrations of methane, sulfate, ferrous iron, nitrate and nitrite. For reductive dechlorination of chlorinated solvents, that set should also include measurements of dissolved ethane and ethene concentrations.