Regional
Aquatics
Monitoring
Program

RAMP

2005 Technical Report

REGIONAL AQUATICS MONITORING PROGRAM

2005 Technical Report

FINAL

Prepared for:

RAMP STEERING COMMITTEE

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The RAMP chairperson during the 2005 program year was Preston McEachern (AENV). Fred Kuzmic (Albian Sands) was chair of the Technical Program Committee, Laura Smithies (Suncor) was chair of the Finance Sub-committee and Michele Toma (Syncrude) was chair of the Communications Sub-committee following (held jointly with CEMA and WBEA).

RAMP is a multi-stakeholder environmental monitoring program that is composed of representatives from industry; municipal, provincial and federal governments; local aboriginal groups and environmental organizations. Effective implementation of the RAMP requires a number of contributors. We would like to thank the following:

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EXECUTIVE SUMMARY

OVERVIEW

The Regional Aquatics Monitoring Program (RAMP) was initiated in 1997 in association with mining development in the Athabasca oil sands region near Fort McMurray, Alberta. RAMP is an industry-funded, multi-stakeholder initiative that monitors aquatic environments in the region. The intent of RAMP is to integrate aquatic monitoring activities so that long-term trends, regional issues and potential cumulative effects related to oil sands development can be identified and assessed. In 2005, RAMP was funded by Syncrude Canada Ltd., Suncor Energy Inc. Oil Sands, Albian Sands Energy Inc., Shell Canada Ltd., Canadian Natural Resources Ltd., Imperial Oil Resources, Petro-Canada Oil and Gas, OPTI Canada Inc./Nexen Inc., Husky Energy, and Total E&P Canada Ltd.

The Regional Municipality of Wood Buffalo in northeastern Alberta is the RAMP Regional Study Area (RSA). Within this area, a Focus Study Area (FSA) has been defined and includes watersheds where oil sands development is occurring or planned, including:

- Lower Athabasca River and Athabasca River Delta;
- Major tributary watersheds/basins of the lower Athabasca River system including the Clearwater-Christina rivers, Hangingstone River, Steepbank River, Muskeg River, MacKay River, Ells River, Tar River, Calumet River, and Firebag River;
- Select minor tributaries of the lower Athabasca River (McLean Creek, Mills Creek, Beaver Creek, Poplar Creek, and Fort Creek);
- Specific shallow lakes in vicinity of current or planned oil sands development; and
- A selected group of 50 regional acid-sensitive lakes.

RAMP incorporates both stressor- and effects-based monitoring approaches. Using impact predictions from the various oil sands environmental impact assessments, specific potential stressors have been identified that are monitored to document baseline conditions, as well as potential changes related to development. Examples include specific water quality variables and changes in water quantity. In addition, there is a strong emphasis in RAMP on monitoring sensitive biological indicators that reflect the overall condition of the aquatic environment. By combining both monitoring approaches, RAMP strives to achieve a more holistic understanding of potential effects on the aquatic environment related to oil sands development.

The scope of RAMP focuses on key components of boreal aquatic ecosystems, including:

- Climate and hydrology – monitors changes in the water level of selected lakes and in the quantity of water flowing through rivers and creeks in the Athabasca oil sands area;
- Water and sediment quality in rivers, lakes and the delta – reflects habitat quality and potential exposure of fish and invertebrates to organic and inorganic chemicals;
- Benthic invertebrate communities in rivers, lakes and the delta – serve as a biological indicator and are important components of fish habitat;

- Fish populations in rivers and lakes – biological indicators of ecosystem integrity and are a highly valued resource in the region; and

- Water quality in regional lakes sensitive to acidification – early warning indicator of potential effects related to acid deposition.

The overall analytical approach for the 2005 RAMP Technical Report builds on the methodology used in previous years and the RAMP Technical Design and Rationale document. Key features of the analysis for 2005 were as follows:

- Conducted at the watershed/river basin level, with an emphasis on watersheds in which development has already occurred, as well as the lower Athabasca River at the regional level;

- Used a set of measurement endpoints representing the health and integrity of valued environmental resources within the component;

- Where possible, applied criteria (e.g., criteria used in oil sands EIAs, AENV, CCME guidelines, generally-accepted EEM effects criteria) for determining whether or not a change in the measurement endpoints has occurred and is significant with respect to the health and integrity of valued environmental resources within the component; and

- Designated areas of the RAMP FSA whose RAMP aquatic resources have been potentially influenced by oil sands development activities, and used this information to determine which RAMP stations and monitoring years were to be designated as operational or baseline for the purposes of data analysis.

Satellite imagery was used in 2005 in conjunction with more detailed maps of Athabasca oil sands operations provided by a number of RAMP industry members to estimate the type, location, and amount of land disturbed by oil sands and other development activities. It is estimated that there were approximately 92,000 ha of land change as a result of various activities within the RAMP FSA as of 2005, of which about 57,000 ha was directly oil sands development-related, and the remainder (about 35,000 ha) due to other human activities, primarily logging. The percentage of the watersheds with land change from oil sands development activities varies from less than 1% for many watersheds (Steepbank, MacKay, Ells, Christina, Firebag, Horse, and Hangingstone), to 5% to 10% for the Poplar, Muskeg, and all the smaller lower Athabasca River tributaries from Fort McMurray to the mouth of the Firebag River, to more than 10% for the Beaver, McLean, and Tar watersheds.

The following sub-sections briefly summarize results of the monitoring assessment for each watershed evaluated as part of the 2005 RAMP. Results from a regional perspective are also provided, as well as the Acid-Sensitive Lakes component, which focuses on regional lakes.

WATERSHED-LEVEL ASSESSMENTS

Lower Athabasca River

The large size and flow of the lower Athabasca River means that there is high year-to-year variation in RAMP aquatic resources, much of which is due to natural factors; 2005 was no exception in this regard. In 2005, as in 2004, all hydrologic measurement endpoints were calculated to be approximately 1% less than they would have been without oil sands development activities within its drainage basin. There were no discernable changes in water or sediment quality conditions due to oil sands development activities and there is little evidence to suggest that characteristics of key indicator fish populations have changed during the period of increasing oil sands development in the RAMP FSA. Any influences of oil sands development activities on the RAMP aquatic resources of the lower Athabasca River appear to be very minor.

Athabasca River Delta

In 2005, monitoring activities in the Athabasca River Delta (ARD) focused on sediment quality and a benthic invertebrate survey. The ARD is the part of the RAMP FSA that is furthest downstream from oil sands development activities and the status of all RAMP aquatic resources measured in the ARD in 2005 is ascribed to the specific hydrologic conditions that characterized the sampling period of 2005, as well as inherent natural conditions of the dynamic environment of the ARD. There was large spatial variability in sediment quality measurement endpoints throughout the ARD in 2005, including both guideline exceedances and concentrations of measurement endpoints that were either below the 5th or above the 95th percentile for reference baseline ranges. In addition, the characteristics of benthic invertebrate community measurement endpoints in 2005 were very similar to those of previous years. Therefore no influences of oil sands development activities were detected in the ARD in 2005.

Muskeg River Watershed

Monitoring activities in the Muskeg River basin in 2005 included hydrology, water and sediment quality, and benthic invertebrate surveys.

There was evidence of effects of oil sands development activities in 2005, but these appear to be subtle and minor. Cumulative oil sands development in the Muskeg River watershed up to 2005 has decreased mean open-water season discharge by 2%, decreased mean winter discharge by 1.7%, decreased annual maximum daily discharge by 2.9%, and decreased open-season minimum daily discharge by 2.0%. These effects are considerably lower than was estimated for 2004 because the use of satellite imagery to estimate land change resulted in a more accurate estimate of the hydrologically-isolated area within the catchment for 2005. There were oil sands development effects on water quality in Stanley Creek, but this was not manifested in Muskeg River water quality, and fall concentrations of most selected water quality measurement endpoints in 2005 were within regional baseline ranges. Similar conclusions can be made for sediment quality, although the sediment quality data record for the Muskeg River is still relatively limited and characterized by very high variability. There is no evidence of an impaired benthic community in those parts of the Muskeg River designated as *potentially influenced-oil sands*.

Steepbank River Watershed

Monitoring activities in 2005 within the Steepbank River basin included hydrology (Water Survey of Canada station), water and sediment quality and benthic invertebrate community surveys. Although the oil sands development located adjacent to the Steepbank River commenced in 1997, there is little evidence to suggest that oil sands developments have influenced current hydrologic, water quality, sediment quality, and benthic invertebrate community conditions. While some shifts in the benthic invertebrate community were observed at the potentially influenced-oil sands reach of the Steepbank River relative to the reference upstream reach, benthic invertebrate community measurement endpoints were generally within the expected ranges for regional reference conditions.

Tar River Watershed

Monitoring activities in the Tar River watershed in 2005 included hydrology, water and sediment quality, and a benthic invertebrate survey. The Tar River watershed in 2005 showed some changes in RAMP aquatic resources from previous years. The effects of oil sands activities on hydrologic conditions in 2005 was assessed as low based on effects criteria used in oil sands EIAs for mean open-water season discharge, annual maximum daily discharge, and open-season minimum daily discharge. Water quality and sediment quality conditions in 2005 were generally within regional ranges of concentrations for baseline conditions. Finally, generally lower values of benthic invertebrate community measurement endpoints in 2005, and recent downward trends in a number of these measurement endpoints coinciding with the commencement of significant oil sands development activities indicate the possible effects of these activities on benthic invertebrate communities in the lower parts of the Tar River watershed.

MacKay River Watershed

Monitoring activities in the MacKay River watershed in 2005 included hydrology, water and sediment quality, and a benthic invertebrate survey. Data collected in the MacKay River watershed in 2005 indicate negligible changes in hydrological conditions as a result of oil sand activities, little observable change in water quality; and little evidence of effects on benthic invertebrate communities. These 2005 results, plus the relatively small scale of oil sands development activities in the watershed to date indicates that oil sands development is having minor and negligible effects on RAMP aquatic resources.

Calumet River Watershed

Monitoring activities in the Calumet River watershed in 2005 included hydrology, water and sediment quality, and a benthic invertebrate survey. While 2005 was the first year that a portion of the Calumet River watershed was designated as *potentially influenced-oil sands*, RAMP aquatic resources were measured as being similar to previous years. Few measurement endpoints in 2005 exceeded existing environmental guidelines, and few selected measurement endpoints were outside the range of expected reference conditions for similar river systems and habitats in the RAMP FSA.

Miscellaneous Aquatic Systems Potentially Influenced by Oil Sands Activities

This section includes Mills Creek, Poplar Creek, McLean Creek, Beaver River, Isadore's Lake and Shipyard Lake. While some water quality measurement endpoints in these aquatic systems in 2005 exceeded guidelines for the protection of aquatic life, most selected measurement endpoints were within the normal range of regional baseline conditions for reference water bodies and watercourses. There were few sediment quality exceedances in 2005 of CCME ISQG guidelines for the protection of aquatic life, although some selected measurement endpoints exceeded the normal range of regional baseline conditions for reference water bodies and watercourses. Benthic invertebrate communities in Shipyard Lake in 2005 were dominated by taxa tolerant of degraded conditions such as *Chironomus*, *Einfeldia* and ostracods. The community does, however, have a relatively high number of taxa, diversity and evenness relative to Kearl Lake and McClelland Lake, and does contain sensitive groups including representative mayflies and caddisflies.

Firebag River Watershed

Monitoring activities in the Firebag River watershed in 2005 included hydrology, water and sediment quality, and a benthic invertebrate survey. Total runoff in the Firebag River watershed was well above average in 2005; flows were above average for almost the entire year. RAMP aquatic resources of the Firebag River watershed, designated as a reference watershed for 2005, were similar in 2005 relative to previous years. There were few exceedances of water quality environmental guidelines throughout 2005, and practically all measurement endpoints for RAMP aquatic resources that were sampled in 2005 were within the range of expected reference conditions for similar river systems and habitats in the RAMP FSA.

Ells River Watershed

Monitoring activities in the Ells River watershed in 2005 included hydrology, water and sediment quality, a benthic invertebrate survey, a fish inventory, and a fish sentinel species program. Runoff volume in the Ells River basin was 14% above average in 2005. Conditions in the Ells River in 2005 were generally similar to previous years. Although overall flow was higher, water quality, sediment quality, and benthic invertebrate community conditions were within the range of historical regional baseline conditions. The main exceptions to this were PAHs in sediments which were higher in 2005 and in the upper range of regional baseline levels. Fish inventory results indicate Ells River populations are typical of fish populations in other aquatic environments within the Athabasca oil sands area. The first year of sentinel species monitoring in the watershed, using the longnose dace, revealed significant baseline differences in population measurement endpoints of populations sampled at the upper and lower *reference* sites.

Clearwater-Christina River System

Monitoring activities in the Clearwater River and Christina River basins in 2005 focused on collecting baseline data for hydrology, water and sediment quality, benthic invertebrate communities and fish populations via a fish inventory.

Runoff volume and streamflows in both the Clearwater River and Christina River watersheds were above normal in 2005. Water quality measurement endpoints were generally within historical ranges and within the range for regional reference stations. Guideline exceedance of selected water quality measurement endpoints was restricted to nutrients and metals, with more than 50% of nutrient-endpoint combinations exceeding existing guidelines. Concentrations of water quality endpoints were often different from concentrations at the designated reference station. Benthic invertebrate community measurement endpoints were within the range for the appropriate regional reference conditions, although density and richness indices in both sampled reaches of the Christina River and in the lower sampled reach of the Clearwater River were lower than the regional averages for these indices. These results, along with similar 2004 results for water quality and benthic invertebrate communities, indicate upper sampling stations and reaches in these watersheds may not be suitable as reference stations.

A third year of fish inventory work on the Clearwater River was conducted to expand the baseline dataset for this river. Fish community composition, length-frequency relationships external fish health indices, and condition factors were similar to what was found in 2003 and 2004, although there were some shifts in the length-frequency distributions for some species. These measurement endpoints were also similar in 2005 to what has been measured in the lower Athabasca River (with the exception of lake whitefish in the Athabasca River). Information obtained in 2005 continues to support the likelihood that lake whitefish do not use the Clearwater watershed for spawning migration.

Hangingstone River Watershed

Monitoring activities in the Hangingstone River watershed in 2005 included hydrology, water and sediment quality, and a benthic invertebrate survey. 2005 results confirm that the Hangingstone River is a typical lower Athabasca River sub-basin, with RAMP aquatic resources in 2005 within the range of regional baseline conditions for similar watersheds and habitat types. 2005 sampling results confirm that the selected sampling stations are suitable for monitoring possible influences of upstream oil sands development activities.

Miscellaneous Aquatic Systems Not Potentially Influenced by Oil Sands Activities

Miscellaneous aquatic systems designated not potentially influenced by oil sands development activities in 2005 included Kearl Lake, McClelland Lake, and Fort Creek. The RAMP aquatic resources of these aquatic systems had similar conditions in 2005 to previous years, with the exception of lake levels of Kearl Lake which was lower than normal during parts of the year. All water quality measurement endpoints were within the range of expected reference conditions for aquatic systems in the RAMP FSA and there were very few exceedances of existing environmental guidelines.

REGIONAL PERSPECTIVE

Climate and Hydrology

All hydrologic measurement endpoints for the lower Athabasca River are calculated to be lower in the operational hydrograph than in the baseline hydrograph, indicating these measurement endpoints are less than what they would have been in the absence of oil sands development activities. The percent change varies from -0.2% to -1.1% depending on the specific measurement endpoint and are similar to 2004 estimates. The reported changes in hydrologic measurement endpoints for 2005 would have been assessed as Negligible or Low in many oil sands EIAs. Therefore, based on the available hydrologic and oils sands development information, it appears that changes in hydrologic conditions in the lower Athabasca River up to and including 2005 have been negligible to low.

In 2005, the surface water hydrology of the RAMP FSA was relatively unchanged from what it would have been in the absence of oil sands developments; approximately 85% of the area of the RAMP FSA experienced no hydrologic effect in 2005, and approximately 14% was assessed to have experienced a negligible effect. A small part of the RAMP FSA (Tar River watershed) is assessed to have experienced a Low hydrologic effect (as defined by oil sands EIA criteria) of oil sands development activities for the hydrologic measurement endpoints. Differences between 2004 and 2005 are due to an overall decrease in calculated, rather than actual, hydrologic effect. The use of remote sensing technologies in 2005 to estimate land changes from oil sands development activities enabled a more accurate estimation of different types of land changes, in contrast to assumptions made in 2004 that entire leases were changed by oil sands development activities.

The assessment, therefore, is that there has been little change in surface water hydrology throughout the RAMP FSA in relation to oil sands developments.

Water Quality

While water quality in the Athabasca River in fall 2004 was influenced strongly by higher than average flows and associated increased sediment loads, flows in fall 2005 were more similar to historical average conditions, and water quality in the Athabasca River in fall 2005 reflected the more normal flow regime. Total suspended solids were lower in fall 2005 than in fall 2004 at all stations sampled. Concentrations of water quality analytes typically associated with TSS, including total aluminum, total iron, and total phosphorus, were also generally lower in 2005. Fall 2005 results for most selected water quality measurement endpoints were within the range of regional baseline concentrations. Ion balance characteristics varied within a narrow range for all stations regardless of sampling year or longitudinal location along the river.

For 2005, there was a slightly higher frequency of guideline exceedance of water quality measurement endpoints at stations designated as *potentially influenced-oil sands* (16.5%) than at stations designated as *reference* or *potentially influenced-other* (14.1%). With respect to frequency with which concentrations of water quality measurement endpoints are below the 5th or above the 95th percentile of regional baseline ranges, there was a slightly higher frequency of such concentrations in 2005 at stations designated as *potentially influenced-oil sands* (26.1%) than at stations designated as *reference* or *potentially influenced-other* (24.4%). Neither difference is statistically significant.

On the basis of these results, it is concluded that there was no difference in water quality between areas of the RAMP FSA designated as *potentially influenced-oil sands* and areas designated as *reference* or *potentially influenced-other*.

Sediment Quality

Although highly variable, sediment quality in the Athabasca River in 2005 was generally within the range of previous years' observations. Overall, concentrations of all sediment quality measurement endpoints at the single Athabasca River station sampled in 2005 were below applicable CCME/ISQG guidelines in fall 2005. In addition, concentrations of selected sediment quality measurement endpoints measured in fall 2005 were between the 5th and 95th percentile of reference baseline ranges, with the exception of carbon-normalized total hydrocarbon concentrations, which were greater than the 95th percentile

For 2005, there was a slightly higher frequency of guideline exceedance of sediment quality measurement endpoints at stations designated as *potentially influenced-oil sands* (25.7%) than at stations designated as *reference* or *potentially influenced-other* (22.5%). With respect to frequency with which concentrations of water quality measurement endpoints are below the 5th or above the 95th percentile of regional baseline ranges, there was a lower frequency of such concentrations in 2005 at stations designated as *potentially influenced-oil sands* (23.8%) than at stations designated as *reference* or *potentially influenced-other* (37.5%). Neither difference is statistically significant.

On the basis of these results, it is concluded that there was no difference in sediment quality between areas of the RAMP FSA designated as *potentially influenced-oil sands* and areas designated as *reference* or *potentially influenced-other*.

Benthic Invertebrate Communities

In 2005, the percentage of benthic invertebrate community indices whose observed values were greater than two standard deviations from their regional baseline average in locations designated as *potentially influenced-oil sands* was low and basically the same as for reaches designated as *reference* or *potentially influenced-other*. The distributions were qualitatively and statistically identical. It is concluded, therefore, that in 2005 there was no difference in benthic invertebrate communities between areas of the RAMP FSA designated as *potentially influenced-oil sands* and areas designated as *reference* or *potentially influenced-other*.

Fish Populations

2005 fish inventory results from the lower Athabasca and Clearwater rivers indicate:

- While there is some species-specific variability in fish population measurement endpoints (i.e., relative abundance and condition factor), there are no significant trends in this regard, and there is little evidence to suggest that characteristics of key indicator fish populations have changed during the period of increasing oil sands development;

- Overall, additional inventory data obtained using a standardized approach is required to permit appropriate trend analysis, and determination of the natural variability associated with designated measurement endpoints. Once the range of natural variability has been estimated, appropriate criteria can be developed for determining the presence of a significant change. Ongoing assessment and evaluation of the data gathering and analysis procedures used in the lower Athabasca River fish inventory should result in substantial enhancements to the component, particularly with respect to its monitoring function; and

- The fish inventory planned for the Clearwater River in 2006 will provide the third year of baseline inventory data for this system. This will allow for amore in-depth assessment of the natural variability in fish populations in the Clearwater River.

Fish tissue results from the lower Athabasca River in 2005 indicate that:

- Concentrations of mercury in fish tissues occur at levels that pose a high risk to subsistence fishers, a variable risk for recreational fishers and general consumers;

- Concentrations of metals (other than mercury) in tissues of sampled fish generally pose a low risk to human health; and

- All tainting compounds in lower Athabasca River fish tissue were present at concentrations well below all applicable guideline, indicating that fish palatability is not likely an issue.

However, mercury concentrations present in water and sediment in the Athabasca oil sands development area are generally at or below detection limits. Furthermore, fish tissue mercury concentrations observed in 2005 were similar to those observed historically. These findings indicate that mercury concentrations in fish tissue are naturally high in the Athabasca oil sands areas and these high levels are not related to oil sands developments.

The sentinel species monitoring program was conducted for the first time in the Ells River watershed in 2005. Results indicate that:

- Longnose dace have some limitations for use as a sentinel species in the Ells River watershed, particularly as they are a comparatively slow growing small-bodied fish species, which has some implications for determining growth rates and changes in population distribution between sampling efforts;

- Despite these limitations, it was possible to track growth shifts in young-of-year fish between sampling periods and detect significant differences in population distribution between and with sampling sites; and

- Condition factor, the primary endpoint used in the sentinel species monitoring program, was greater for fish sampled at the lower site in the Ells River.

Because of the limited regional scope of the sentinel species monitoring program, and very preliminary nature of results from the Ells River, these results have not been extrapolated to the level of the RAMP FSA.

Acid-Sensitive Lakes

There has been no significant change in the overall chemistry of the 50 RAMP lakes in 2005 compared to previous years. In addition, the 50 RAMP lakes in 2005 displayed similar characteristics to the lakes contained in the database on regional lakes created by the

NO_xSO_x Management Working Group (NSMWG), although there were distinct differences that reflect the effects of the lake selection process used by RAMP. RAMP lakes have a slightly narrower pH range and a lower median pH value, lower total alkalinity, lower conductivity, lower mean and median concentrations of the principal cations (calcium, magnesium, sodium and potassium) and the sum of base cations, lower mean and median concentrations of major anions (chloride, sulphate and titration bicarbonate), and greater DOC and nitrate concentrations.

Detailed results of trace metal analyses indicate that, while the concentration of most trace metals has been low and often below detection limits, there are lakes and sub-regions with high concentrations of some metals. In particular, the Birch Mountains have the highest number of metal concentrations above 95th percentile. The high metals concentrations in these lakes are most likely natural in origin rather that the result of anthropogenic emissions.

Exceedances of Alberta and CCME Surface Water Quality Guidelines for Protection of Aquatic Life were observed for aluminium, cadmium, iron and mercury. The guideline exceedances are scattered throughout the sub-regions, with a large representation from lakes in the Birch Mountains and the Stony Mountains sub-regions, consistent with the high metal concentrations found in lakes from these two regions.

Of the RAMP lakes in 2005, 17 out of 48 lakes (35.4%) had a calculated Critical Load (CL) exceedance; this is in contrast to a calculated CL exceedance frequency of 45.8% (22 of 49 lakes) in 2004. These rates of CL exceedance are considerably higher than the rate of 8% reported for 399 oil sands lakes in a 2006 NSMWG lake sensitivity report using the same models. The higher rates of exceedance in the RAMP lakes reflect a bias in selecting the study lakes where the most poorly buffered lakes were preferentially selected for sampling. The high rates of CL exceedance do not indicate imminent acidification for these lakes.

Results from the seasonal sampling program conducted by AENV from March 2004 to September 2005 show that there are very significant changes in the chemistry of the RAMP lakes over a year. The shallow ponds, in particular, show extremely large decreases in pH and increases in base cations, Gran alkalinity, DOC and nitrates in the winter season. These changes may be the result of a large proportion of the water volume in these small water bodies freezing during the winter.

While the results of the Mann Kendall trend analysis show a number of significant trends, these trends were often inconsistent with any conceivable acidification scenario. Based on the inconsistent results of the trend analysis, there is no evidence to conclude that there have been any significant changes in lake chemistry over the length of the ASL component in RAMP.

RECOMMENDATIONS

Following the watershed-specific assessments and regional assessments, a number of recommendations were identified for the purpose of refining the program and increasing the monitoring value of RAMP activities. These recommendations are outlined in detail in Section 7 for each RAMP component for consideration during the design of future monitoring programs.