6.0 APPENDIX A – LEAK DETECTION ORGANIZATIONS & PRODUCTS

This information summary reported by certain vendors, researchers and websites is not comprehensive, contact sources for more details

Organization & Website	Product & Application	Deployment & Technology	Status - Capacity or Operational Limits	Additional Notes
Site inspectors	Site observation - GM & SCVF	On site & areal - distressed Vegetation, bubbling in standing water & observed vent flow	Legacy – requires a minimum leak rate - wetlands & ground cover may conceal leaks	Some sites difficult to access on ground
Site inspectors	Site observation with imaging - GM & SCVF	On site & areal - IR camera – thermal imaging (OGI)	Legacy & emerging - spot checks only impacted by wind, intermittent flow	Some sites difficult to access all year by ground
Site inspectors	Hand-held gas detectors - GM & SCVF	On site - LEL & other portable gas detection methods	Legacy & emerging - spot checks only impacted by wind, intermittent flow	Some sites difficult to access all year by ground
Site inspectors	Latex glove - SCVF	On vent piping - observe inflation	Legacy - detection on low rate leaks	Tape to pipe for min 24 hours
Site inspectors	Bubble test - SCVF	On vent piping - count bubbles in water manually for 10 min	Legacy - low rate & intermittent leaks may not be detected with 10 min test	AER rule in ID2003-01, currently being converted to a Directive
Sensit Technologies https://www.gasleaksensors.com/	Sensit PMD Portable Methane Detector - GM & other types of leaks	On site, walking and vehicle - infrared (IR) Absorption Spectroscopy with an electronic narrow band pass filter	Legacy - detects methane from 1 ppm up to 100% volume, impacted by wind, intermittent flow	Optional GPS and data logging. Bluetooth data transmission communication of real time and stored data.
InnoTech Alberta https://innotechalberta.ca/	Photography & thermal imaging of plumes. Isotope analysis of water, gases and solids - SCVF, GM & other leaks and materials	On site and UAV (drone) - gas concentration measurement via portable multi-gas monitors, on-site gas sample collection & analytical laboratories for determining concentrations of GHGs, VOCs	Legacy & emerging - remote monitoring & data access via cellular communications. Methane rates as from 0.25 SCCM to 5000 SLPM - process control and data acquisition.	On-site micrometrological data collection via 4 quick-deploy weather stations, Computational plume dispersion modelling
Capstone Oilfield Services Ltd. https://doullsite.com/	Consulting services, proprietary method for identifying/ measuring external/ internal GM if GM known/ suspected	On site - requires trained field technician - SCVF & GM	Legacy - measurement of gas, water and other substances from surface casing, ground, water, ice & air	An original innovator in this space. Formerly Doull Site Assessments.
Chemistry Matters Inc. http://www.che	Consulting services - SCVF measurement & GM detection with sampling	On site - Gas & fluid sampling with best practices for sample collection & forensic identification. Gas isotope interpretation, gas	Legacy & emerging - sampling and SCVFs and GM identification of gases	Data analytics for data mining, machine learning, multivariate analysis and modelling.

mistry-matters.com		composition interpretation, geochemical forensic analytics.	and liquids source leaks using isotopes.	
University of Calgary https://ucalgary.ca/pomelo-methane-system	Research & consulting PoMELO – truck mounted emissions measurement system - upstream wells and facilities	Truck mounted methane leak detection - laser spectrometer, anemometer, GNSS, data fusion, machine learning localization and quantification algorithms.	Research & emerging - single blind testing report: https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/BUT8GA	Follow-up with OGI on same site visit. Analysis through computer techniques and machine learning.
Gchem Ltd. http://www.gchem.ca/index_files/Page352.htm	Consulting services, database of analyses forensics and equipment rentals - SCVF sampling & measurement and GM detection with sampling	On site monitoring - gases & water isotope laboratory services & interpretation, with formation mapping to identify the sources. Have advanced methods to ensure data integrity.	Legacy & emerging – have system for measuring SCVF with steam and collecting samples for isotope analysis. Developed methods for long term sample preservation. System for monitoring cut and capped wells.	Have a method of collecting gas samples while drilling. Conduct energy forensics (fingerprinting) /using chemical and isotope analysis. Isotope analysis in areas with populated database
Surface Solutions Incorporated http://surfacesolutions.ca/	Consulting Services - SCVF & GM with sampling	On site and remote real time monitoring - proprietary and patented VentMEDIC to measure methane vent emissions.	Legacy & emerging - sampling for carbon isotope analysis. Methane venting emissions measurement (.0144 – 300m3/day) taking millisecond data.	Developing advanced equipment and procedures for measuring SCVF and GM. Automated reporting function. Can convert CH_4 emissions to CO_2 equivalent.
Ventbuster Instruments Inc. https://www.ventbusters.com/	Ventsentinel® - detect various oilfield venting to atmosphere	On site and remote monitoring. Patent Pending, sensor on principle of thermal mass flow & heat transfer as a function of flow velocity. Method called Constant Temperature Anemometer (CTA).	Legacy & emerging – gas emissions monitoring from 0 ml/min to 500 m3/day with same device. Real time direct and continuous data transmitted to an IoT Platform. Working pressure to 5.0 MPa.	Currently deployed for CHOPS field trials, to be deployed on above-ground & under-ground tank vents, instrument air vents, compressor seals and SCVF.
Kairos Aerospace http://kairosaerospace.com/	LeakSurveyor - moderate to high rate leaks	Light fixed wing aircraft at 1000 m altitude. Measure the absorption of reflected sunlight by methane molecules with simultaneous optical image and GPS data collection.	Legacy - difficult access areas. with methane spectrometer (optical data). Limited by low leak rates & weather conditions.	Provide site-specific images of methane emissions.
LiDAR Services International Inc. http://www.lidarservices.ca	Sensor mounted on aircraft	Airborne 3D gas imager aerial verification - use Bridger Photonics' Bridger Photonics' GML	Legacy - real time monitoring. Limited by low leak rates, weather conditions	Incorporate wind data

GHG Sat Inc. https://www.ghgsat.com/	Flight: GHGSat-AV; Satellite: Fabry-Perot interferometer - moderate to high rate leaks	Satellite & aircraft detection of methane emissions, near real time monitoring	Legacy & emerging - satellite detection of substantial leaks and large facilities. Aircraft spatial resolution to < 1 meters.	Future plans for drones.
Bluefield Technologies https://bluefield.co/	Satellite detection of moderate to high rate leaks	Small satellites methane detection - optical sensors see light reflected from ground, methane blocks part of the light spectrum and leaves a spectral signature	Emerging - sensors see 20,000 spectral lines that make up the methane fingerprint. Proprietary technology	Planning to deploy their own proprietary technology on their own satellites
Skywatch Space Applications Inc. 2000 https://www.skywatch.com/	Aggregator and vendor of satellite data	Partners with satellite companies and innovators - do not do analytics	Legacy & emerging - can acquire existing satellite data and can task satellites for data. A few countries and areas are off limits.	Objective is to provide low cost data to innovators
MethaneSat LCC https://www.methanesat.org/about-methanesat/	Acquires data from Satellite companies using MethaneSat - optical data	Interprets spectrometer analysis data MethaneSat satellite sensors pick up sun's reflected IR radiation and parses to obtain methane unique fingerprint	Emerging - planning to launch their own satellite, provide free results to others. Focusing on emissions from oil and gas sector.	Subsidiary of Environmental Defense Fund
GeoVerra https://www.geoverra.com/	ExACT emissions detection vehicle - site venting and emissions	Mainly vehicle based, detect leaks in real time - OGI camera linked to GPS to detect methane and other greenhouse gases	Emerging - not temperature limited	Mapping & GIS services

7.0 APPENDIX B - LEAK MEASUREMENT ORGANIZATIONS & PRODUCTS

This information summary reported by certain vendors, researchers and websites is not comprehensive, contact sources for more details

Organization & Website	Product & Application	Deployment & Technology	Status – Capacity or Operational Limits	Additional Notes
Inspectors	Bubble test - SCVF	On vent piping - count bubbles in water manually for 10 min	Legacy - low rate & intermittent leaks may not be detected with 10 min bubble test.	AER rule in ID2003-01, consider alternates to bubble test.
Various companies	Positive Displacement Meters (PD) - SCVF	On vent piping - PD meters	Legacy - gas only, low rate limitation.	Lower measurement limit varies with devices.
Calscan Solutions http://www.calscan.net/	Consulting services, Hawk vent gas meters - tanks, compressor seals, pneumatic, SCVF & CHOPs open casing vent	On vent piping - digitized PD diaphragm meter or gas turbine with temperature & pressure probes, pressure build up and fluid sampling.	Legacy & emerging, measures 0.028 m3/day to 340 m3/day depending on model, Div 1 Class 1. Use turbine meters for flow rates up to 1800 m3/d.	Manufacture & sell several types of meters, flow computers & data loggers. Provide field testing, rentals and consulting services. Requires technician on site.
Calscan Solutions http://www.calscan.net/	Consulting services, Hawk SGA (steam gas analyzer) - thermal wells with steam in surface casing vents	On site - SCVF on SAGD wells, portable condenser knocks out steam remaining gas measured, and sample taken for analysis.	Legacy & emerging - measures steam mass flow rate, remaining gas rate, percent of H2S & percent of hydrocarbon. H2S isotope sampler to assess well integrity.	Service supplied to SAGD operations in Alberta. Does not work well in winter conditions currently.
Capstone Oilfield Services Ltd. https://doullsite.com/	Consulting services, VentMeter™ - On site & remote SCVF monitoring	Access to data on mobile devices. Measures vent flow rates lower than 7.0 mL/year. Gas & water vent measurement on thermal wells.	Legacy & emerging - automated real time monitoring & remote valve actuation. Vent flow testing and pressure build up, with sampling.	Remote satellite monitoring option. Class 1 div 1 rating. Requires trained field technician. Formerly Doull Site Assessments.
Capstone Oilfield Services Ltd. https://doullsite.com/	Consulting services, proprietary method for identifying/ measuring GM	On Site – requires trained field technician - SCVF & GM	Legacy & emerging - measurement of gas, water and other substances from surface casing, ground, water, ice & air.	An original innovator in this space.
Gchem Ltd. http://www.gchem.ca/index_files/Page352.htm	Consulting services, SCVF & GM measurement with sampling including thermal wells	On site - system for monitoring cut and capped wells. Gases & water isotope laboratory services & interpretation, with formation mapping to identify the sources.	Legacy & emerging - measuring SCVF with steam and collecting sample for isotope analysis. Method of collecting gas samples while drilling. Conduct energy	Database of analyses forensics isotope analysis in areas with populated database. Equipment rentals. Developed methods for long term sample preservation. Have methods to ensure data validation.

			forensics (fingerprinting) /using chemical and isotope analysis.	
Chemistry Matters Inc. http://www.chemistry-matters.com	Consulting services & SCVF measurement & GM detection with sampling	On site - soil gas measurements, gas isotope interpretation, gas composition interpretation, geochemical forensic analytics.	Legacy & emerging - sample & identification of source leaks for gases and liquids. Identification of SCVFs and GM using isotopes.	Data analytics for data mining, machine learning, multivariate analysis and modelling. Gas & fluid sampling best practice for sample collection for forensic identification.
Ventbuster Instruments Inc. https://www.ventbusters.com/	Consulting services, Ventbuster® Compact & portable, solar powered commercial product in 2020.	On site - SCVF Assemblies, per AER Directive 20. Real time direct and continuous SCVF flow rate, pressure & temp and shut-in pressure. Method called Constant Temperature Anemometer (CTA)	Legacy & emerging - Emissions monitoring from 0.04 ml/min (+/- 1 bubble/min) to in excess of 450 m3/day with the same device. Sensor operates on a variable flow channel on principle of thermal mass flow & heat transfer as a function of flow velocity.	Original intent was for use by engineers for SCVF evaluation / diagnosis and wellsite supervisors for SCVF repair. Data is transmitted to an IoT Platform. Gas medium only, no liquid measurement. Working pressure to 7.0 MPa.
Surface Solutions Incorporated http://surfacesolutions.ca	VentMEDIC & consulting Services - SCVF & GM	On site and remote - real time SCVF measurement & monitoring use proprietary measurement of vent emissions	Legacy & emerging - sampling for carbon isotope analysis	Also use the CALSCAN Hawk Vent Gas Meter, measurement with sampling. Ability to convert CH_4 emissions to CO_2 equivalent.
University of Calgary https://ucalgary.ca/pomelo-methane-system	Consulting services, PoMELO – truck mounted emissions measurement system. Upstream wells and facilities.	Truck mounted methane leak measurement using Laser spectrometer, anemometer, GNSS, data fusion, machine learning localization and quantification algorithms.	Research - follow-up with OGI in a single visit work practice	Analysis through computer techniques and machine learning.