Distinguishing anthropogenic impact using hydrochemical and spatial analyses, southeastern Piceance Basin, Colorado

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Abstract. Water resources in semi-arid western Colorado are scarce and especially vulnerable to impact by petroleum production activities. At Mamm Creek natural gas field in the southeastern Piceance Basin, gas well completion problems caused gas seepage into a local stream. Using this case to define impact, hydrochemical data from the surrounding area was analyzed. Normalized and standardized inorganic data from 648 water samples were separated into five statistically distinct groups, representing water facies, using hierarchical clustering. One cluster was low TDS, Ca-Mg-HCO_3 water consistent with natural background. Other clusters showed "impacted" signatures: high Fe-Mn, high TDS Na-Cl or high TDS Na-SO_4-HCO_3. Samples with high Fe-Mn signatures are found primarily at the methane seep location where reducing conditions dominate during active seeping. Samples with high Na-Cl signatures are indicative of formation water from the gas production zone. Samples with high Na-SO_4-HCO_3 signatures represent impact by a third source as yet undetermined.

Average groundwater methane concentration by year is positively correlated with the growing number of wells in the study area. Water samples with high Fe-Mn signatures also have elevated benzene and methane concentrations, indicating direct petroleum contamination. In contrast, Na-Cl samples have the highest average methane concentrations, but low benzene concentrations suggesting migration from the petroleum source has degraded the benzene. Since there is no apparent correlation between water facies and structural trends, this implies that impacted waters may not be derived from natural leakage of deeper formation waters, but from the additional transport pathways caused by well drilling.

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