Thank you for the opportunity to comment on this well-constructed scoping document. Unfortunately, I only learned of its existence several days ago, so I have not had the time to provide a more comprehensive review. In addition, I'll primarily limit my comments to the topics of human health and ecological risk. Recognizing that this document refers to an HIA, I'll try to avoid the discussion of quantitative risk assessment. Finally, time constraints did not allow me to include literature references, which I can provide at a later date, if necessary.

First, I'll comment on a few matters of general interest:

1) The authors focus almost exclusively on the fracking fluid additives, which constitute between 0.5 and 2% of the total mixture. There was little discussion of hazards associated with effluent leaks and other possible contamination of the post-drilling process.
2) There are several statements and bar graphs shown in which the authors report higher levels or incidence rates, without a complete analysis of the data. For example, on page 29, they discuss another UNGDP study, where they indicate that [the median air concentrations] of benzene were 2.6 ug/m^3 (range 0.9-69 µg/m^3) and 0.9 µg/m^3 (range 0.1-14 µg/m^3) at points <= 0.5 miles from the well pad and points >= 0.5 miles from the pad, respectively. Given the large variability in these findings, I believe that the statement that the benzene concentrations were "significantly higher" nearer the well is premature. A t-test or non-parametric test, as appropriate, should be conducted to validate the conclusion.
3) When illustrating cross-regional differences in the bar graphs, the authors would be well served to maintain the same color scheme throughout. The fact that they sometimes change the region represented by each color is confusing.
4) Comparisons of studies across geographic regions must be tempered by a knowledge of the baseline conditions in each region. For example, divalent cation and radioactive metal concentrations are typically (but not always) higher in the Rocky Mountain states.
5) Finally, you may want to emphasize that it's to the industry's advantage to comply with the document's recommendations now rather than later. As more complete fracking impact assessment data are made available, the industry may be faced with even greater costs related to increased toxicity testing or reverse engineering requirements.

Now I'll comment on specific findings and conclusions within the document:

1) The use of 25% and 75% extraction scenarios (p. 31) is an excellent method for assessing the range of probable impacts.
2) Given the elevated air emission HQ findings of residents near well sites (p. 36) and the increased incidence of smoking in the two counties of concern (p. 144), further discussion of the relationship between these two findings, especially with regard to co-carcinogenicity and effects of PM2.5 exposure in smokers, is warranted.
3) Similarly, the relationship between findings of neonatal and childhood impacts in near-well residents (pp. 36-39), and infant mortality (pp. 153-154) should also be considered. Although inadequate health care is a contributory factor to infant mortality, contaminant exposure to teratogens or contaminants that delay fetal development may exacerbate the issue. If known teratogens are found the fracking mix, previous research and/or risk assessments should be consulted, and exposure scenarios should be considered.

4) Although not directly a toxic effect, I think that the authors should emphasize that, in addition to the massive amounts of water used in these operations, that freshwater is a dwindling resource that few species can live without.
5) Fig. 10-11 is a good concise diagram of water contamination pathways. Does the reuse box refer to spills during the recycling process?
6) The authors' point (p 45) on monitoring radionuclides other than radon is well-taken. They may want to further indicate that carcinogenicity and chromosomal aberrations are the chief hazards of concern for radioactivity exposure. Cells that frequently undergo mitosis, which is much more common in children, are the most susceptible. Overall, systematic statements about acute and chronic effects are difficult because of differences in the radioisotope (or combination of radioisotopes) involved, the exposure level in rems, distance from the source, and the types of radiation produced. Nevertheless, the EPA has provided a useful guideline (http://www.epa.gov/radiation/understand/health_effects.html) of threshold exposures at exposure levels ranging from 5 to 2000 rems.
7) The Fernow Experimental Forest application is interesting because it found severe community-level effects after being exposed to fracking fluid levels that were within regulatory guidelines. With respect to further ecological analysis, I would suggest that two or three exposed target species be tagged to get a better understanding of movement, eating, drinking, and spawning behaviors . In particular, these species, such as deer and grouse, should be part of the human food chain. The results of this study can then be compared to measured concentrations of fluid components in land, water, and air, to provide a measure of potential impact to these species.
8) If a stream system may be compromised by the results of fracking operations, damage to the stream system itself, water column species, and organisms bound to sediment may be at risk. I would suggest a search of the literature to find relevant studies that address this issue.
9) The EPA has a long history of guidelines and references regarding the risk of cumulative exposures (Sect. 10.3.7). In addition, the IPCS (http://www.inchem.org/documents/harmproj/harmproj/harmproj7.pdf) have introduced a series of models that could be useful for assessing combined exposures to multiple chemicals. The authors may want to review these sources and make reference to them in Sect. 10.3.7.
10) Several fracking studies have found families of contaminants in which toxicity data is unavailable for all but a few. A classic example are the PAHs. The authors may want to recommend the use of Decision Trees or Quantitative Structure-Activity Relationship to estimate the hazard potential of these substances, and to suggest where additive or multiplicative effects are in place. Of course, this proposal assumes that the industry is willing to name the constituents of the fracking fluid, and allow technicians to monitor soil, air, and water samples post-drilling.
11) With reference to H_2S exposure (p 80), the authors may want to note that the gas is odorless but lethal at higher concentrations. This property has led to the deaths of several occupational workers.
12) The CGDP provides an excellent overview of industry and health group requirements to ensure a safer fracking experience.
13) The authors may want to include studies of air flow modeling for the most offensive airborne contaminants. (R19, p. 92).
14) The authors may want to change the text in R24 (p. 93) to 'Periodic soil **and sediment** monitoring should be conducted…'

15) In Sect. 12.7.2 (p. 96), it may be wise to employ community-based educators who can hold modular sessions on the fracking process and associated health impacts. This issue is partially addressed in R41.
16) In section 15.4.1 (p.136), I think that a stronger statement needs to be made regarding the monitoring of groundwater for fecal indicator species, and how elevated levels should be treated.
17) For Fig. 15-11, p. 138, the TRI results should be normalized by population in each region.
18) The authors appear to be misstating the facts in Sect. 15.4.3. According to the bar charts of Figs. 15-12 and 15-13, the state of Maryland is leading in both cancer risk and the RHI. Either the bar charts or the authors' conclusions need to be modified.
19) In Sect. 15-5 (p. 141), the term 'region' should have been defined earlier in the document.
20) Both Allegany and Garrett counties have high life expectancies, compared to Maryland. This finding may at least partially explain the elevated cardiovascular and cerebrovascular deaths (Figs. 15-22 and 15-23, p.151) in these two counties, compared to the state.
21) In Appendix A, the authors have a tendency to state that one locale has a higher incidence than another, when, in fact, the heights of the two bars are virtually identical. This tendency is particularly noticeable in Figs. 15-15 (p. 143), 15-19 (p 148), 15-25 (p 153), 15-26 (p 154), and 15-27 (p 154). I would suggest that the authors run chi-square tests on the results, to verify which comparisons are statistically significantly different.
22) With regard to deaths from individual causes I found it curious that Allegany had larger (sometimes much larger) mortality rates than Garrett (Figs. 15-18a, 15-18c, 15-18e, 15-18f, 15-19, 15-20, 15-21, 15-22, and 15-24). Yet the All-Cause mortality rate (Fig. 15-25, p 143) between the two counties is virtually the same. I would recommend further investigation as to why mortality rates for individual disorders differ between the two counties.

Charles Shore
M.S., Toxicology
Gaithersburg