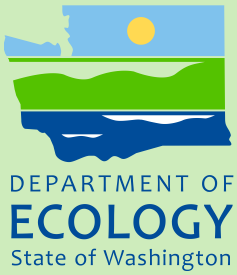
Response to Comments

Roofing Materials Assessment: Investigation of Toxic Chemicals in Roof Runoff from Constructed Panels in 2013 and 2014



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Publication and Contact Information

These appendices are linked as a supplementary document to the report at:
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Purpose of This Document

The Washington State Department of Ecology (Ecology) distributed a draft report to the Roofing Task Force (RTF) members in late May 2014. The draft report was also posted to the web. Ecology requested that persons commenting on the draft report submit their comments by June 27, 2014.

Ecology received over 120 comments from the RTF members. We are grateful for the time and effort RTF members invested in their comments. In this Response to Comments document, we captured and responded to all comments received. Note: We copied reviewer comments into the Comment and Suggested Change column without correcting any grammar, punctuation, or spelling problems.

Following the changes we made to the report in response to the comments, our technical editor provided many helpful suggestions which were also incorporated into the final report.

Item Number	Page Number	Section or Subsection Heading	Commenter's Name	Comment and Suggested Change	Department of Ecology Response
1	11	Abstract	Mike Hubbard	Paragraph 5 it says "TPO without flame retardant" That is not a true statement. It just does not have a brominated fire retardant.	The word brominated has been added.
2	56	PBDEs	Mike Hubbard	In the third sentence "Ecology sampled phthlates" I think this is supposed to be PBDE's.	Corrected.
3	99	Phthalates	Mike Hubbard	Second paragraph after the heading 5 line it says "only treated wood shake, EPDM, and TPO panels released" I think this should say "showed" or a term like that because I don't think that either the EPDM or the TPO released a phthalate. None are used in those products. I cannot speak for the treated wood shake. You have a better chance for contamination in the lab for TPO and EPDM.	Language changed to indicate that phthalates were detected in the runoff from the three types of roofing materials.
4	98, 11	PAHs	Mike Hubbard	I am not sure I agree with the PAH levels in EPDM they were lower than the glass in the second round.	When the concentrations of PAHs from all 13 sampled events were taken into consideration, a statistically significant difference was found. The sentences following that statement offer caveats.
1	1	Publication and Contact Information	ARMA	Can you provide clarification on why data from this project will not be available on Ecology's EIM website?	The runoff data are not considered "environmental data" because they do not represent the quality of stormwater that one would sample from roof system runoff. EIM does include stormwater outfall data when the outfall represents multiple sources and/or land uses. It does not include Best Management Practices effectiveness monitoring—which would be somewhat similar to the data generated by this project. The data will be available on the website as an appendix to the report.
2	11		ARMA	Add evaluation of aftermarket products to recommendations in last sentence.	Addition made.
3	11		ARMA	In last paragraph add "modified built-up" after "built-up"	Addition made.

Item Number	Page Number	Section or Subsection Heading	Commenter's Name	Comment and Suggested Change	Department of Ecology Response
4	21	Findings	ARMA	Table ES-2 seems in conflict with the text prior to it which says that the only leaching from asphalt roofs is copper from AR shingles. Is the difference that the differences with glass controls although statistically significant are not considered to be practically significant? I thought the zinc was removed when the full data set of 20 storms was considered.	Table ES-2 was corrected based on the *Results* and *Discussion* sections for both the AAR and the ASA. Also the following sentences were added in the text preceding ES-2 to help clarify the issue. "Those statistically significant differences indentified in Table ES-2 do not identify the magnitude of the differences. In some cases the significant differences identified were minor value differences, but consistently higher."
5	22	Findings	ARMA	I though zinc leaching was reuded from round 1 to 2 in both kinds of asphalt shingles.	You are correct. The reduction in zinc was added to the sentence.
6	24	Recommendations	ARMA	First sentence seems wrong -- is this without subtracting of glass control values? If so it wrongly implies that new roofs are the cause.	I can understand how the sentence could be misleading. It has been eliminated
7	24	Recommendations	ARMA	Aren't the after market products for more than moss?	Yes. The word "moss" was eliminated.
8	52	Results	ARMA	In Fig 8 it is hard to believe the ZN is elevated above the glass control, and it is hard to believe that the ZN for AR shingles did not go down between first 10 and last 10 and for last ten was not same as glass control. In the case of AR shingles the first 10 points are ALL above the last 10 points.	Thank you for pointing out the inconsistencies. The *Discussion* section, where statistical analyses are discussed, was checked for accuracy. The *Findings* sections and both the Executive Summary and the body of the report were altered where statements were incorrect. The zinc concentrations in the runoff from the AAR and ASA were not significantly different from the glass across all 20 events. And Table 19 indicates that the runoff from both AAR and ASA declined in zinc concentration in Round 2.

Item Number	Page Number	Section or Subsection Heading	Commenter's Name	Comment and Suggested Change	Department of Ecology Response
9	54	Results	ARMA	Table 7: It should be noted more clearly in the table that many samples were only sampled for PAHs 3 times. In fact if the data were presented as %of times sampled that PAHs were sampled nearly alll would be at 100%. As it is it looks as if the asphalt materials had more samples with detectable PAHs. They did not -- they were just tested more often (10 times rather than 3).	I agree that more standardization is a good idea. So all of the numbers have been changed to percentages.
10	55	Results	ARMA	Table 8: same issue as in Table 7.	I agree that more standardization is a good idea. So all of the numbers have been changed to percentages in Table 8.
11	65	Discussion	ARMA	Table 11: in tables like this it would be useful to not just flag the significant differences but to give all the α values. I suspect that the AR asphalt shingle comparison is not much different than the asphalt shingle without AR but one is just above the 0.05 gate and one just below, and giving the α would show that nuance. Same comment for all the comparisons.	The Mann-Whitney statistics in Tables 11, 13, 15, 17, and 19 have been revised to remove the concentrations of the glass panels in comparing Round 1 with Round 2 data. These calculations were performed by hand and compared to the α statistic, and exact α values were not calculated.
12	77	Discussion	ARMA	Figure 21 indicates that there is no significant difference between AAR or ASA and glass control for zinc. This is counter than what is indicated in Table ES-2 which listed zinc as being significantly different than control for both AAR and ASA. This was also indicated in the text in the executive summary. CLEARLY the ASA is not significantly elevated in zinc as its median is 25% lower than the glass control, its max is half the glass control, its min is lower than the glass control and the ASA box plot is nearly identical or even lower than the control. AAR is not so clear but at any rate the report needs to be consistent on ZN in asphalt shingles.	See ARMA comment #8 above. Inconsistencies have been resolved.
13	79	Discussion	ARMA	Need to add ASA and PVC to the list of materials at top of page that saw a significant decrease in zinc from round 1 to 2 according to table 19	ASA and PVC were added.
14	90	Discussion	ARMA	The implications for why the metals released in this study were so low compared to the literature is incomplete to my mind. I would add the potential for materials to be different Europe to US, possible biased high values in other studies, and conditions in the NW being different (pH, rain extent, airborne pollution, etc).	Where such implications could be reasonably made, they have been added to this section of the report.

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15	98	Discussion	ARMA	Comment on BUS being higher in PAHs than BUR or BUA. It was pointed out in the session that this was entirely a round 1 observation. Round 2 results are essentially identical with the three panels. And Round 1 BUS is very similar to Round 2 results. The real question would seem to be why round 1 BUA and BUR were so low. I think this point deserves mention. Beyond that the glass controls are very similar to BUS.	Additional discussion has been added indicating that the high BUS was due to Round 1 results, which were not different from the GLO results. And then BUA and BUR were significantly lower in Round 1 than GLO.
16	102	Conclusions	ARMA	Same inconsistency on zinc with asphalt shingles. Says they did not release elevated levels one place and then says they did another. A good look at the data indicates there was no increase if all 20 rain events are considered for ASA and the report indicates no elevation for AAR as well in an earlier section. Need to clean up this inconsistency.	See AMRA comment #8 above. Inconsistencies have been resolved.
	102	Conclusions	ARMA	First bullet says none of the BUR panels were significantly higher but "however" they were lower in lead. I would use "in fact" rather than "however" since to me however implies a different conclusion.	"However" was changed to "In fact."
	103	Conclusions	ARMA	At top of page a sub-bullet is missing for the BUS line.	Correction made.
1	11	Abstract	Tobiason	4th and 5th paragraph call out "new" roofing materials, but there is no context to indicate what "new" means overall and with respect to Round 2, and "new" is not used in prior paragraphs. Later in report same thing, " new" used inconsistently. Just say it once in the methods/materials and delete "new" elsewhere to avoid confusion.	Wording changes have been made in the *Abstract.* However, Ecology has only studied the roofing materials for a year. It is important to reiterate the concept that the materials were newly installed throughout the findings and conclusions.
2	11	Abstract	Tobiason	4th paragraph, not clear if EPDM had statistically higher PAHs than glass control.	This paragraph was eliminated from the Abstract due to a word count over 300-word limit.
3	11	Abstract	Tobiason	4th paragraph last sentence should be clarified about whether referring to total PAHs across all panels.	See previous response.
4	11	Abstract	Tobiason	last paragraph, delete "harmful", no basis in this report of what is and isnt harmful.	Change made.
5	11	Abstract	Tobiason	2nd paragraph seems a bit generalized. There were 9 panels that had higher metals than controls. In second sentence "highest " doesn't seem to fit when 2 each panels and 2 each metals are being compared. Third sentence is redundant with first sentence.	Clarification not deemed necessary. Third sentence was eliminated.

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6	11	Abstract	Tobiason	3rd paragraph points out just two of the panels and metals that didn't decrease in round 2 while there were several others that were statistically higher than controls but that also did not decrease: AAR (As, Cu), CTI (As, Pb).	This paragraph presents general statements, including identifying the panels that released the highest metals concentrations. To go into additional detail would expand the abstract beyond its word limit.
7	11	Abstract	Tobiason	while comparing rounds, consider stating that controls were lower in round 2 for arsenic, which suggests the decreases for certain panels that werent higher than controls are insignificant.	This paragraph presents general statement. To go into additional detail would expand the abstract beyond its word limit. The revised Mann Whitney statistics now use the glass control panel concentrations (by storm event) in the statistic. So effects of the changing glass concentrations should be moot.
8	11	Abstract	Tobiason	seems appropriate for the abstract to echo the other recommendations mentioned on page 105, e.g., fate and transport, after market products; it only covers the first two (aging and other components)	A general statement has been added to point to all the recommendations.
9	17	ES	Tobiason	replace "hazard' with "risk" since hazard assessments don't get at exposure whereas this is a core area of risk assesssments. Also, at 8 pages, the Executive Summary is lengthy. Since the ES is cut and paste into the Conclusions section, my comments on Conclusions would be applicable to the ES.	Change made. Executive Summary has been shortened.
10	21	Table ES-2	Tobiason	errors in several metals listed as higher than controls that don't agree with boxplots in discussion and is not clear if referring to round 2 or overall results (preferred). For the CPR pannel, lead was not higher than controls in either round. Pb missing for CTI. Blank entries appear to need "none".	Errors corrected.

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11	36	Data Qualifiers	Tobiason	2nd paragraph: Need to explain that J flags were also used for high end values (Cu for CPR with MSD problem) and for flagging metals results affected by rinsate blanks, not just for values between MDL and RL, which becomes confusing in data analysis and plots. It appears J flaged values <RL were reported at the RL value which was also used to calculate medians and other stats (see comment on Cd from CPR panel). (also I dont see the CPR Cu J flag issue called out on pg 37 about metals QC and MSD spike concentration problem, was this fixed in Round 2?).	The reader is referred to the more detailed qualifiers used in the electronic data deliverables (EDDs) (Appendix D), which provide these explanations. No additional description is needed in the body of the report. Note also that the J flagged values were reported at the concentration measured by the lab and those values were used in calculating medians. Data in the EDDs still have the more detailed flags such as M (MS/MSD spike issue) and Be (equipment blank contamination). These can be found in Appendix D. However, all the data in tables have been "rolled" up into Js, Us or Rejs.
12	37	Metals Analysis	Tobiason	Where are the equipment rinse blank data reported? I don't see any metals results in Appendix B that were qualified as described in last paragraph, i.e. where results were <5x rinse blanks. It would be helpful to provide a equipment rinse blank data summary table.	Equipment rinse blank data are provided in the EDDs.

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13	43	Field Data	Tobiason	Specific conductance results bear some further evaluations and discussion as commented in Round 1 report. The value in the data should be realized. SpCond provides insight into unmeasured solutes. Why aren't statistical evaluations provided as done for most all other parameters? Events 11 and 19 produced some of the highest SpCond across all materials and controls, suggests atmospheric dep source? Other issue? Particularly for CTI and WOS, SpCond medians and ranges were significantly higher than for other panels, yet these two materials had relatively low concentrations of metals, often no different than controls (Cd, Cu, Zn). For CTI, one could expect the conrete matrix to release Ca and Mg which would account for the higher SpCond and these two ions impart potentially beneficial levels of hardness that would tend to help mitigate potential toxicity of divalent metals. The highest SpCond came from the WOS, appeared to have decreased somewhat over time, and may bear futher investigation into unmeasured solutes that might be beneficial (DOC?) or of other concern.	While pH and specific conductance were not the major focus of this report, Ecology added an analysis using non-parametric statistics for both Sc and pH. Also these data are being provided on the web so it is available for anyone for additional analysis.
14	43	Field Data	Tobiason	pH analysis: similar to above comment on SpCond, pH data have minimal evaluation and the brief discussion is limited to the control panels. Results for pH appear to be significantly different for certain roofing materials. Materials with mineral granules (AAR, AS, BUR, BUS) appeared to increase rainfall pH 1-2 points over glass controls. The pH of CTI was notably much higher than glass controls. These are potentially important benefical impacts of reducing natural acidity of rainfall and its potential downstream effects in reduced mobility of metals in drainage infrastructure (e.g. metal gutters, downspouts, bioretention soils, etc). Discussion and Conclusion allude to pH differences between this study and the literature so taking pH forward would help.	See response to previous comment.
15	43	Field Data	Tobiason	sulfur dioxide: the Centralia coal fired power plant is 20 miles due south (upwind during prevailing wet weather) of the test site and the plant is still in operation. It seems some more local SO2 data would be related to this plant, and could help explain local acidic rainfall?	We checked with the Air Quality Program and no SO2 data specific to the area are monitored.

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16	46	Table 6 Volumes	Tobiason	several (Round 1) max volumes exceed the reported max volume of sample container (56.8L) mentioned on pg 32	The maximum volume on page 32 was calculated from the nominal 15-gallon volume. When calculated based on the depth and diameter of the containers, the actual maximum volume was 63.1 liters. This change has been made on page 32. The one exceedance of that may have been an error in reading the measuring stick. A footnote has been added to Table 6.
17	47	Total Metals	Tobiason	In the explanation of the ggplots, you should mention that non-detect means U flagged results and that many J flagged results when indicating <RL are plotted at the RL value, and often show up as lines of points for repeat J flag values.	The narrative has been changed indicating that the vertical lines show U-flagged values. However for those values between the RL and the MDL, J flags were applied and the values plotted. This is in accordance with the QA Project Plan.
18	59	Volumes	Tobiason	1st paragraph: event 5 actually shows relative low and consistent sample volumes of 15-19 L, so check the sentence about which event was omitted as extraordinarily high.	Event 5 was the only event in which the median collected rainfall was 130% of the runoff available. As suggested in the text, this was attributed to a consistent measuring error on that date.
19	59	Volumes	Tobiason	2nd paragraph: I think you mean "runoff sample volume" not "volume of rain recovered" in this text and in Figure 12 caption.	Changes made.
20	59	Volumes	Tobiason	2nd paragraph: talks about Figure 12 in terms of event #s but event #s are not shown on Figure 12 to relate to text Also, it would he helpful to translate the 0.5cm resolution into a volume for volume error context in Figure 12.	Additional information has been added to the text.
21	61	Total Metals	Tobiason	would be helpful to condense Table 11, 13, 15, 17 and 19 into one table showing which materials had lower/higher/no change in all 5 metals between rounds, and which were higher than controls in pooled dataset, see next tab in this workbook as an example. Table ES-2 is a start but is incomplete, has errors, lacks the Round 1 vs Round 2 trend analysis, and is in different format than data tables thru rest of report.	Table ES2 has been revised in the Executive Summary that pulls together all the data across all 20 events.

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22	61	Total Metals	Tobiason	Tables 11,13,15,17,19 show statistically significant decreases in round 2 yet many of the pooled results were statistically less than controls, which suggests that the decreases were actually not significant. Suggest limiting the lower/higher analysis to only those panels that were overall higher than controls to keep the focus on meaningful results and away from statistical artifacts.	Table ES-3 has been added to the *Executive Summary* that pulls together all the data comparing Rounds 1 and 2. Additionally, the tables in the *Discussion* have been limited to those differences detected by a modification to the statistic test as described in response to Tobiason comment #29.
23	61	Total Metals	Tobiason	How were non-detects (both U and J flagged results) handled in the calculation of medians and other statistical analyses? Were J flagged results (those <RL) always used at the RL value, even when high frequency?	A paragraph has been added to *Laboratory Analysis and Data Quality* section to describe how non-detects were handled in calculating medians and for statistical comparisons and citations provided. The QA Project Plan specifically requested that the lab report values between the MDL and the RL (and J flagged). The MDL is the concentration that can be detected above zero and with a 99% confidence that it is above zero. For a pilot study such as this, that level of confidence was deemed sufficient to meet the MQOs.
24	62	Arsenic	Tobiason	the max value of 1.4 µg/L arsenic from the CPR panel is clearly an outlier. The GST control for this same event (#6) was 0.7 µg/L (1/2 the CPR result), which was the highest for GST, suggesting an anomaly. Given the size of the dataset now, some form of outleir test and related qualifier seems appropriate or at least the idea of potential outliers should be mentioned.	Because concentrations are a function not only of the materials, but also the precipitation amount, intensity, and the length of the antecedent dry period, Ecology believes it would be premature to begin eliminating outliers.

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25	62	Total Metals	Tobiason	Overall in discussion section of total metals, might want to do a global check on "release" because it is used a bit inconsistently/interchangeably with other terms, e.g.,"leach". Later in the Discussion (pg 91) the report does acknowledge atmospheric dep (wet and dry) vs. what may have been released/leached from the roofing material itself. Thus, the notion of "release" is more suited to later synthesis of results and the total metals section should just present teh runoff concentrations as is. For example, the opening sentences for As (pg 62) and Cd (pg 65) should read more like the opening sentence for copper (pg 69), then explain where results were consistently and significantly higher than controls, then you can point out the implication of material releases. Consider that for 70 possible panel-metal combinations, only 16 showed consistent/significant higher than glass controls.	In the *Introduction*, the word release is defined for the purposes of this report as a footnote. In other sections, some wording changes were made where statistically higher concentrations were found in the runoff from a panel type as compared to the glass control.
26	62	Summary Table	Tobiason	Tables 10, 12, 14, 16, 18 provide too few summary statistics and would benefit by adding the non-detection frequency, and providing the coefficient of variation (CV) because the min/max/median don't give any measure of variability. You could also indicate by shading or a * footnore which medians were not significantly different from the controls. This provides consistency between the box plots and the tables for the agregate dataset.	Indicators of significant differences have been added. Variability and numbers of non-detected values can be assessed by ggplots in the *Results* section.
27	64	Arsenic	Tobiason	Figure 13 for WOS doesn't have a * as text on pg 64 indicates it would	Asterisk added to correct Figure 13.
28	65	Cadmium	Tobiason	Table 11 the "a" code isnt shaded in this table like the similar tables for other metals, please make consistent or explain why Table 11 is different.	Shading added.

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29	65	Arsenic	Tobiason	EPDM didn't show difference from glass control, so how is the potential increase in Round 2 significant?	The section and subsequent metals sections were revised when comparing differences between rounds. The Mann Whitney test was modified by subtracting the concentrations of the glass controls prior to comparison of the Round 1 to Round 2 results. This eliminated findings of statistically lower concentrations in Round 2 when the Round 1 was not differentiable from the glass. See also response to Tobiason comment #22.
30	65	Arsenic	Tobiason	top of page, 2nd sentence, hyphenated part doesn't seem to fit subject.	Sentence revised to clarify.
31	65	Cadmium	Tobiason	1st sentence begins overly broad "all panels released.." in comparison to 1st sentence for arsenic. The many non-detects for Cd in the gg plots suggest no Cd was released at all, for most panels.	Sentence changed.
32	66	Table 12	Tobiason	The CPR Cd medians are completely dependent on the calculation method used for estimating the J and U flagged values since all 20 resutls were either J or U flagged. The medians reported in Table 12 appear to assume the reported values, is that valid for so much low censored data?	Both J and U flagged data were used to calculate median values in the cadmium table. Most of the medians are at one-half the MDL, indicating cadmium was not detected most of the time (also evident from the ggplot). The median values for the CPR and TWO panels indicate that cadmium was detected, and for TWO those values were significantly greater than the glass control. See also response to Tobiason comments #23 and 33.

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33	66	Cadmium	Tobiason	Hard to imagine the CPR panel had significantly more Cd than controls when all the CPR Cd results were either J or U flagged. 30% of the results were non detects (U) plus the 7 results J flagged at 0.02 indicate the values used in calcs/stats would have significant bearing on conclusions. Is a statistical test even possible with this much low censoring?	Helsel (2005) indicates that standard nonparametric tests such as rank sum tests used in this report can be calculated by assigning the non-detected values a value below the detection limit and less that the lowest observation. "The ranks will efficiently capture the information in the data including the proportion of nondetects, accurately representing what is known about the data. Test results are reliable, not based on 'information' that is not known, and not dependant on the substitution of arbitrary values." J flagged data were also used based on response to Tobiason comment #23. For the Cd concentrations from the CPR panel, recalculation of the statistic indicated that across both rounds of the study, there was no difference from the glass control. However the results in Round 1 were significantly greater than the glass for the following reasons: Eight of the J flagged Cd concentrations were greater than the U flagged glass concentrations. Where both CPR and GST concentrations were U flagged or were equal, the subtraction resulted in zero and the data were not included in the statistical comparison. Thus the sample size for this comparison was reduced from 10 to 8. The text has been revised to reflect this.
34	66	Cadmium	Tobiason	Table 12, 14, 16 have various values in bold (Table 10 is all bold), and some tables have no bold values, is bold text suppsoed to indicate something? If so, then tables should add footnote to explain.	Footnotes for bold have been added.

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35	66	Cadmium	Tobiason	last sentence seems an over generalization that panels and controls "released" cadmium when so many were non-detects, why would glass be expected to "release" Cd? Consider checking parallel statements made (or not made) for other metals	Wording was changed.
36	69	Copper	Tobiason	2n sentence, delete the second half of the sentence "…althought the median copper concentration…" and let the values in Table 14 speak for themselves. No other medians are compared and the apparent difference in the medians between CPR and TWO is probably less important than the changes over time suggested in Round 2.	Wording was changed.
37	70	Copper	Tobiason	The last sentence isnt clear if it applies to all 3 AS reps or just the one, which I believe is its intent, and what it is trying to say can only be inferred, so consider instead "Thus, the round 2 results suggest that the higher copper released initially in round 1 by AS-2 was a short lived anomaly ~~had leached out~~.	Wording was clarified.
38	71	Copper	Tobiason	3rd sentence: add "AS" after "asphalt shingle" to be clear and check that all other references include the panel abbreviations (noticed a few others missing)	Document checked for roofing codes.
39	71	Copper	Tobiason	You could refer to the Towson University copper roof study that so far has also not shown significant decreases in Cu over time in the first year since construction/testing.	Added based on SETAC paper.
40	75	Lead	Tobiason	why would only lead from wet deposition be sorbed on certain panel materials and not other metals? What about idea that the glass was a source of lead that could explain why the controls were higher lead than panels?	This discussion has been changed to indicate the frosted glass as a potential lead source.
41	78	Zinc	Tobiason	The PAZ panel included painted galvanized fasteners exposed to rainfall in addition to the drip edge possibility as another source of increasing zinc (i.e. paint failure on the fasteners).	While the painted fasteners showed no signs of failure over the course of the study, this has been added to the narrative.
42	78	Zinc	Tobiason	4th paragraph, comparesWOS and AAR round 2 to control, but other metals sections have not not compared round 2 to control, only round 2 compared to round 1 (trend). Were there other panel-metal combos where round 2 results were less than control but werent in round 1? Appears to be visually the case for zinc from CPR in Fig 22.	WOS and AAR were unique in that they released significantly more metal in Round 1, but not when considering both rounds of data. Hence, they were called out in the narrative. Language clarification has been added concerning the WOS and AAR panels. The zinc in runoff from the copper panel was not significantly different between the Rounds.

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43	79	Zinc	Tobiason	bullet list of lower zinc in Round 2 doesn't include AS and PVC which Table 19 indicated were lower in Round 2	Corrections have been made and narrative descriptors added.
44	80	Correlations	Tobiason	in next to last paragraph, several sentences should be clarified to indicate they are referring to inverse relationships found by oters, which appears to be true in all cases mentioned.	Inverse and positive have been added, as appropriate, throughout this discussion.
45	80	Correlations	Tobiason	Here is another place to be clear on how the many U and J flagged values were used in calcs/stats. How does all this uncertainty factor into each of the 4 types of correlation analysis?	See response to Tobiason comments #23 and #33.
46	80	Correlations	Tobiason	just an idea, wondering if cumulative rainfall since panel installation might be a meaningful metric for correlation analysis and long term aging/weathering. Event-wise correlations don't take into account the overall patterns of expsoure and are probably confounded by the time variable: the same rainfall in round 1 may have resulted in higher concentraion than same rainfall in round 2 due to age and cumulative exposure.	The scope and budget for this project do not allow for additional analyses to be performed (other than those already addressed in this response to comments). The data will be available on the website for people to conduct additional analyses.
47	81	Table 20		While many of the correlations were significant for rainfall, peak intensity, and dry antecedent period, many of the metals concentrations were too low for most of the correlations to be meaningful. Where detection frequency was low, and where either or both rounds were < controls, it seems there would be little meaning in correlation analysis and the statistics are artifactual (the signals are just too low to begin with compared to those that were truly significant). On the other end, 12 of the 16 panel-metal combos that were > controls had statistically significant inverse correlations with precipitation, and 4 didnt, this is what you may want to stress, and also point out in conclusion.	This section has been revised to highlight correlations where the panel concentrations are significantly higher than the glass by round.

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48	82	Correlations	Tobiason	As examples of above issues, page 82 2nd sentence: the only arsenic concentrations in the low slope panels that were significant were from the PVC, all the rest were <<controls, so the inverse correlations with precip don't seem that meaningful for the other panels. Page 85, last paragraph, dry antecedent period is only significant for explaining copper or zinc from a few panels. Page 87, 2nd paragraph, the significant negative correlation between dry antecedent and zinc for the BUA is based on very low zinc concentrations, all values were J flagged, apparently at or near the RL.	See response to Tobiason comment #47.
49	83	Correlations	Tobiason	specify the duration for the peak intensity metric in the text and in Table 21 title and Figure 24 caption, is it 15 min?	Clarified.
50	83	Correlations	Tobiason	last paragraph has some typos	Corrected.
51	86	Table 22	Tobiason	for CPR panel, the dry antecedent period isnt really a signficant variable in explaining arsenic, lead or zinc since these metals were very low and mostly U or J flagged, and boxplots show these metals were not significantly different from glass control.	See response to Tobiason comment #47.
52	87	Correlations	Tobiason	middle of page, about event 11, you mean it had the second lowest amount of rain, not second highest	Corrected.
53	88	Mass Loads	Tobiason	2nd paragraph, its hard to imagine copper being "released" by ZIN material, it has no copper in its metallurgy by design and the Cu concentraions were all very low, mostly J flagged results near the RL	Language in this section has been changed.
54	88	Mass Loads	Tobiason	last three bullets are very good distillations of study results and important information for readers and potential users of study data, these should go in conclusions.	These statements were reiterated in the Conclusions.
55	90	Comparison to PSTLA	Tobiason	2nd paragraph: I think you mean "...were then compared to the median values used for the release estimates…"	Sentence re-phrased.
56	90	Comparison to PSTLA	Tobiason	Why are only Round 2 data compared to PSTLA? Most of the rest of the report makes a good comparison and summary for both rounds. Table 24 should provide total study medians to compare with PSTLA. Also, Table 24 needs to state study result values are medians.	Rationale for this comparison was added to the narrative. Comparisons with Round 1 data are found in Winters and Graunke (2014).

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57	90	Comparison to PSTLA	Tobiason	3rd paragraph, 1st sentence isnt clear what you are comparing to (presumably the PSTLA value) and is not clear what you mean by the CPR copper results were within 70% of one another. The RPD between the PSTLA value (1690) and the Round 2 median (1790) is 16%, not 70%, and the overall RPD was 12%.	Clarification added.
58	90	Comparison to PSTLA	Tobiason	2nd bullet, there is no foundation provided for the apparent inference that somehow environmental zinc concentrations are high and could be explained somehow by other zinc sources not studied here (bare galvanized steel). Suggest deleting this bullet.	Literature citations added to provide foundation.
59	90	Comparison to PSTLA	Tobiason	last bullet; good point, scale factors important and indicated in literature and probably limit applicability of this study's results, echo in conclusions.	Conclusions modified to include.
60	91	Table 24	Tobiason	the copper value of 22 for "metal" in the PSTLA portion of this study is not the value used by Ecology in PSTLA 2011. While you are correct in the value of 22 (thanks, based on my recalcs and our discussion), Ecology did not use this value in PSTLA and if they had, the relative rankings of copper from roofing would change substantially. Please use the same value for copper/metal roofing (355) cited in the Round 1 report as the value in Table 24 in the Round 2 report. Please modify footnote a to include the corrected value of 22 to the footnote. Also, I'd really appreciate it if you could reword the footnote text because it can be misconstrued to make it look like I made the goof, when the error was made somewhere between Ecology and Clark (I've been trying to get Ecology to recognize and correct it for over a year). The footnote "a" second sentence should read instead something like "Ecology 2011a values were based on a misreading by Clark (2008) of a chart reported by Tobiason (2004)."	Changes made.

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61	91	Table 25	Tobiason	Comparing ranges to medians in this table is apples and oranges, suggest just comparing study medians (corrected for controls) to the literature medians. How meaningful are negative values in this table? Perhaps easier to interpret if negative values were omitted and footnote added. Also note that Clark 2010 is apparently unpublished so can it really be considerd "literature"? Can you provide the Clark 2010 document?	Our rationale for comparing ranges was to prevent people from applying the medians to other studies. As the report points out, concentrations are a function of a host of factors including run length, precipitation amount, antecedent dry conditions, to mention a few. However with that said, because the medians are now provided in the *Executive Summary*, there is no reason to exclude them from the table in this section. The data from Clark are available upon request.
62	92	Table 25	Tobiason	Tobiason (2004) is repeated under Galvalume section, delete the 2nd entry	Repeat removed.
63	92	Table 25	Tobiason	how can this report cite itself in this table and in reference list?	Change made.
64	92	Table 25	Tobiason	Table title should indicate the study results had controls subtracted. There are many blank cells in this table, should they be "NM"? Perhaps "NM" isnt needed and the blanks can speak for themselves with a suitable footnote.	Change made
65	96	4th paragraph	Tobiason	FYI, Bill Taylor was not an author of the Taylor 2004 report, his staff authored this report and prepared it under my direction.	Pronouns were changed.
66	96	Copper Roofs	Tobiason	it would be helpful to point out the pH values being alluded to between this study and the others in this paragraph.	The pH was added.
67	101	Conclusions	Tobiason	The conclusion section is a cut and paste from the Executive Summary section and few conclusions are offered. See if you can boil it down and prevent repetition. The 3 bullets on bottom of page 88 are an example of good material buried in the body of the report that would be helpful to reiterate in conclusions.	The *Findings* in the *Executive Summary* have been streamlined. And the bullets from the bottom of page 88 have been worked into the *Conclusions* section. Ecology feels that it is important to include the full spectrum of conclusions in the *Conclusions* section.

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68	101	Conclusions	Tobiason	Under the copper bullet: Disagree with conclusion that CPR panel released Cd. Many of the Cd results were non-detected (U) for the CPR panel, so how can the CPR panel release any Cd in these cases, especially where the glass control was also non-detect (U) in 6 of 20 results? The low end value of 0.005 appears to be the detection limit since all results of this magnitude are U flagged. The highest Cd for CPR was 0.06 J flagged and the GST control was 0.02 J flagged this same event (#5), these are very low concentrations of cadmium and unlikely to pose risk. The statistical tests of difference between the CPR and GST for Cd should be validated with consideration for the U and J flagged results.	See responses to Tobiason comment #23, #25, and #33. The language has also been changed to remove the concept of release where statistical differences were not found.
69	101	Conclusions	Tobiason	2nd paragraph: first sentence it's hard to tell what Ecology thinks are elevated releases (also typo, should be "elevated"). What is considered "leaching" and "releasing" is also a bit vague. Results that were significantly higher than controls is a clear study result.	Sentence has been changed to reflect only significant differences from the glass controls.
70	102	Conclusions	Tobiason	check the bullet for AS: box plot didn't show zinc was higher than controls, which this bullet says was the case.	Correction made.
71	103	Conclusions	Tobiason	add text to clarify which direction the correlations showed in each of the 3 cases , inverse or positve. Also, 2nd bullet should read "peak" rain intensity, not "average" based on results provided. You should offer some conclusions on the predictive ability of the correlations as you suggested on page 87.	Correction and clarification provided.
72	103	Conclusions	Tobiason	Under comparisons to PSTLA, would you recommend that the PSTLA release estimates be updated based on this study's results? However, we have heard that Ecology does not want to make these updates. It is clear that the PSTLA release estimates would be significantly impacted by the new data/new sources identified in this study. It would be instructive to readers of this report if it were more clear that this loop remains to be closed.	Ecology has been clear that updating the PSTLA estimates is not within the scope of this study. However, updating the PSTLA study had been added to the *Recommendations* section. Also note that using runoff concentrations from roofing materials to estimate releases from roofing systems would not be appropriate.

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73	105	Recommendations	Tobiason	1st paragraph: Needs a first sentence about what changes between R1 and R2 suggested an initial aging function, which is the subject of the first paragraph. Otherwise, the first sentence as it is not only doesnt fit, it is overly broad and inconsistent with study results. Specifically, "consistently measureable" isn't broadly appropriate when so many metals results were either U or J flagged low values. Using the RL basis, you could more appropriately say "certain materials released detectable levels of certain metals that exceeded glass controls" (e.g. 16 panel-metal combinations). For example, the CPR panel did not consistently release measureable concentrations of arsenic: 6 of 20 results were U flagged non-detects and all but one of the rest were J flagged values, only 1 of 20 was a detected result, which was also the highest for several other panels and the GST (event #6).	The first sentence of this paragraph has been changed to reflect the issue of aging.
74	105	Recommendations	Tobiason	Why isnt cadmium mentioned in the first sentence?	The first sentence has been changed per previous comment, and the original first sentence has been eliminated.
75	105	Recommendations	Tobiason	3rd paragraph: I still think scale plays an important role in what you found from the ZIN panel vs whole roof study data. While other components are often in play, it seems you are alluding to them as the only reason explaining why your results were lower than the literature for zincalume/galvalume. Your bullets on page 88 and 90 point out the scale issue so this should be another area of recommended study, i.e. full scale roofs.	Such a recommendation has been added.
76	105	Recommendations	Tobiason	Can you mention that the Transport/Fate/Treatment White Paper is being provided and "in-press"? It would he helpful for readers to be prompted to look for this added resource related to the RTF and as prepared as part of the RTF.	A change has been made, and the "White Paper" has been cited in the *Recommendations* section.
77	105	Recommendations	Tobiason	Consider a recommendation for treatment studies. For example, perhaps some of the panels now at WSU extension could be hitched up to some of the mesocosm or bioretention columns for testing removal of arsenic (TWO, PVC), which appears to be little studied.	This recommendation has been added.

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78	105	Recommendations	Tobiason	It seems the absence of PBDEs in runoff from products that did not have PBDEs in their materials didn't answer a key question and might be a false negative, so another recommendation could be to test products with known PBDEs added. PBDE presence was suggested by XRF results in round 1 coupon test but the results suggest the corresponding panel didnt appear to have PBDEs added.	This recommendation has been added.
79	105	Recommendations	Tobiason	update the relative usage of single ply roofing in the Puget Sound Basin since Table ES-2 lists unknown. It should be substantial and would affect the remaining material proportions.	This recommendation has been added in expanded form and combined with Tobiason's comment #80. Only after full roofing systems have been assessed and the information on all roofing uses in Puget Sound basin would it be appropriate to update the PSTLA study.
80	105	Recommendations	Tobiason	update the PSTLA release estimates based on study results, a simple spreadsheet exercise of an hour or two.	See previous response.
1	11, para. 5	Abstract	Gorsuch	What evidence was available to substantiate the following statement "Ecology found that ... did not leach harmful levels of metals or organic compounds"? Toxicity of metals depends on form or metal species, which was not confirmed in this study.	This statement has been changed.
2	18, lines 5-6	RTF Involvement	Gorsuch	Remove "to" in "The RTF members provided substantial comment to in the preparation …"	Correction made.
3	24, line 3	Recommendation	Gorsuch	Remove "the" in "… metals released may change over the 10 to 30-year …"	Not necessary.
4	24, para 3	Recommendation	Gorsuch	Correct spelling of "assess" in "… zinc concentrations in runoff from the Zincalume® (ZIN) and EPDM roofs were an order of magnitude lower than the concentrations used by Ecology to asses sources of contaminants …"	Correction made.
5	24	Note to RTF Reviewers	Gorsuch	In response to RFT reviewers to expand points, I suggest that for the point "Evaluate fate and transport of those metals that based on their concentration and/or their abundance in the region may impact the fresh and marine waters of the Puget Sound basin." that a reference or footnote to the Windward whitepaper "TRANSPORT, FATE AND TREATMENT OF POTENTIAL WATER POLLUTANTS IN STORMWATER RUNOFF FROM ROOFING MATERIALS" be added.	A reference has been added to the *Recommendations* section.

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6	31, para 2	Methods	Gorsuch	Change "rage" to gage in "tipping bucket rain rage".	Correction made.
7	31, para 2	Methods	Gorsuch	"Sample collection containers were not allowed to overflow." How many rain events was this necessary? From Table 6 it appears that this step was unnecessary. If that is the case, then I suggest it be stated. Not collecting the entire volume from a rain event might have resulted in higher levels reported than actually in total runoff.	Sample collection was also terminated for additional reasons that are more clearly described in the subsequent sentences. Not collecting the full storm event simulates smaller events. Because all of the events from Round 1 were between 52nd and 91st percentiles of rainfall within a 24-hour period, we sought to sample smaller events during Round 2.
8	37	Variability	Gorsuch	"Ecology reduced sampling variability by collecting 100% of the runoff from an event." This statement appears to contradict the statement above (comment #7) that sampling stopped when collection containers were full, unless that was never required. Also, on page 61 it was stated "The three built-up roofing types (BUR, BUA, and BUS) consistently recovered less than 100% of the precipitation volume." Suggest a footnote be added to acknowledge exceptions.	Based on our response to Gorsuch comment #8, we do not see a conflict here. The wording in the variability section has been clarified so that it no longer conflicts with the percentage of the theoretical volume collected in the subsequent section.
9	43	Field Data	Gorsuch	There was nothing mentioned about the potential of salinity (chloride) from nearby coastal waters influence on the metal roofs leaching. Was this considered? Swedish researchers (Wallinder et al., 2014) reported corrosion and leaching rates decreases the further the new (bare) metal roofing is from the coastal environment. (See Wallinder et al. 2014, Sci. Total Environment, 472: 681-694.)	Ecology did not measure chloride as it was not identified in the QA Project Plan as a parameter of concern. The predominant wind direction at the site is from the south-southwest. Wind from that direction would carry less chloride because of the greater distance to marine waters. Also, the median specific conductance for the runoff from both glass controls was zero, indicating little potential impact of chloride. This may be one of the parameters to include in the QA Project Plan for future monitoring at the Washington Stormwater Center.
10	69, lines 4-5	Copper	Gorsuch	Remove "for" in "… median copper concentration in the runoff from for the treated wood shake panel …"	Correction made.

Item Number	Page Number	Section or Subsection Heading	Commenter's Name	Comment and Suggested Change	Department of Ecology Response
11	70, last line	Copper	Gorsuch	The statement "The higher copper released initially had leached out." is assumed to be the case for AS, but unless the shingles are analzed for copper this is unproven (conjecture). Suggest that the statement be qualified (e.g., implies leached out or appears leached out).	Sentence was clarified.
12	83, last sentence	Correlations between Concentration and Rain Intensity	Gorsuch	Replace "associated that they" with "were" in "In an outdoor study, Odnevall Wallinder and Leygraf (2001) identified seasonal differences in copper and zinc release rates associated that they associated with relative humidity and fog.	Correction made.
13	87	Using Correlations to Predict Event Concentrations	Gorsuch	Remove "the" preceding "all" in following two bullets: • Arsenic in the runoff from the all roofing materials and the glass control panels; • Copper in the runoff from the all roofing materials	Corrections made.
14	87, last line	Using Correlations to Predict Event Concentrations	Gorsuch	Remove second period in "Thus while one might predict that Event 7 would result in low metals concentrations, Ecology found no consistent pattern.."	Correction made.
15	88, para 1, last line	Total Metals Released	Gorsuch	Remove second period: "… also has an impact on the released metals calculations.."	Correction made.
16	88, 2nd bullet, 3rd line	Total Metals Released	Gorsuch	Change "my" to "may": "… value for a release rate to calculate whole basin releases my not accurately represent the …"	Correction made.
17	95, 1st bullet	Asphalt Shingle Roofs	Gorsuch	Change "rages" to "ranges" in "The Clark (2010) study evaluated shingles with AR. Her reported total metals concentrations were within the rages of the low concentrations…"	Correction made.
18	103, last sentence	Comparison with Puget Sound Toxics Assessment	Gorsuch	Fate and transport were not considered in the estimated amounts of metals reaching Puget Sound, which should be noted in following statement. "However, runoff concentrations used to estimate releases to the Puget Sound basin (Ecology, 2011a) were based predominantly on roofing systems (full-scale roofs with components), rather than roofing materials alone."	Change made to ensure clarification. The statement was changed to describe "estimated **releases within** the Puget Sound basin" which is defined as the 12-county area.
19	105, para 3	Recommendations	Gorsuch	Correct spelling of "assess": "… zinc concentrations in runoff from the Zincalume® (ZIN) and EPDM roofs were an order of magnitude lower than the mean concentrations used by Ecology to asses sources of contaminants …"	Correction made.

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20	105, 1st bullet	Additional Recommendations to be added based on RTF Input	Gorsuch	Regarding the 1st bullet, either include as an appendix, or add a reference to the report for the whitepaper prepared by Windward titled "TRANSPORT, FATE AND TREATMENT OF POTENTIAL WATER POLLUTANTS IN STORMWATER RUNOFF FROM ROOFING MATERIALS". Future considerations should include "Evaluate fate and transport of those metals that based on their concentration and/or their abundance in the region may impact the fresh and marine waters of the Puget Sound basin."	A reference has been added to the recommendations section.
1	19	Executive Summary	Rupar	Here and throughout, the document uses an incorrect full name for EPDM. The correct name is ethylene propylene diene terpolymer, since the substance is a copolymer. The "M" in EPDM indicates a class of rubber having a saturated chain of the polymethylene type, not "monomer." See ASTM D1418, Standard Practice for Rubber and Rubber Latices-Nomenclature, for the naming convention adopted for synthetic rubbers.	Correction made.
2	90	Total Metals Comparisons with the Puget Sound Toxics Assessment	Rupar	I don't see how the pilot study results imply "Existing galvanized metal roofs in the Puget Sound region contribute higher concentrations (and mass) than concentrations measured from the Zincalume® panel in this study." Galvanized steel is present in a variety of exposed uses in construction, most comonly for galvanized hardware and fasteners. Why single out galvanized steel roofs? What about traffic barriers, for example? The report did not include data on market share or square footage of exisitng galvanized steel roofs. Most galvanized steel currently used in roofing has a factory color finish. Bare galvanized steel continues to be used for metal roof flashings, but that use already is covered in the first bullet on this list.	Language clarified to differentiate between existing galvanized metal roofs and the newer Zincalume products that result in lower zinc concentrations according to the literature. The commenter is also referred to the Ecology 2011 study to understand the sources of zinc originally used for estimating releases in the Puget Sound region. See especially Appendix B of the Sources report (Ecology, 2011).
1	20	Findings	Vondran	Insert statement "Meaningful comparisons of product types from different panel conditions (i.e. steep slope vs low slope) are not valid".	The concept of the inappropriateness of direct applicability of panel conditions has been added to a number of sections throughout the report including the *Findings* section of the *Executive Summary* in *Comparisons with the Puget Sound Toxics Assessment*, and *Comparisons with other Literature*.

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2	21/22	Findings	Vondran	Metals released from High-Slope and Low-Slope Panels" Where concentration ranges are provided, also refer to the median values.	A table with median values has been added to the *Executive Summary*. The long narrative has been removed, and the reader is referred to the *Conclusions* section, where the median values have been added.
3	95	Galvalume/ ZINCALUME	Vondran	Insert statement "Zinc runoff rates are strongly influenced by corrosivity, rain rates, panel size, panel orientation, etc. Therefore, the zinc concentration from ZINCALUME® steel will vary considerably from site to site and test to test, in additional to temporal variation. However, the relative difference between different products in the same set of test conditions is likely to be consistent.	A paragraph similar to that recommended has been added.