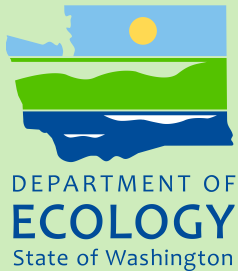


Response to Comments

Roofing Materials Assessment: Investigation of Toxic Chemicals in Roof Runoff



February 2014

Supplement to Publication No. 14-03-003

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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 October 2013. The draft report was also posted to the web. Ecology requested that persons commenting on the draft report submit their comments by December 27, 2013.

Ecology received approximately 280 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	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
1			Tobiason	Windward Environmental	Supplemental white paper on transport, fate and treatment of roof runoff: per our conversation at the last RTF meeting and on the phone 12/18, we will provide a draft white paper for the RTF to review and include as an added section in Ecology's Phase 2/supplemental report planned for late spring 2014. This approach will provide the context in the Ecology report and prevent having a 3rd party white paper floating around. We will provide a draft for review before the next anticipated RTF meeting in May.	The supplemental white paper that was discussed at the RTF should include next steps, such as fate and transport, as well as the other issues identified by the RTF. The independently written white paper will not be completed in time for inclusion in this report, but may be appended to the Round 2 report, depending on input from the RTF.
2	8	abstract	Tobiason	Windward Environmental	Abstract is a bit brief, so consider expanding to note the following items: 1) list all material types and trade names, 2) the 2 different slope types, 3) glass control in each slope group yielded similar results, 4) only replication was for non-AR asphalt shingle group, 5) ID industry collaboration (total # of entities representing suppliers and trade groups) and their help in study design and installation, 6) suppliers provided materials (i.e. you didnt go get them at Lowes and Home Depot like Clark did).	The abstract is limited to 300 words.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
3	8	abstract	Tobiason	Windward Environmental	Continuing suggestion on expanding abstract, consider adding what the results suggest and limitations: 1) study results showed the PSTLA roofing source rankings would change using this new regional data (some go up, some go down), 2) aging may need characterization (e.g. Phase 2 is underway and supplemental report coming mid 2014), 3) environmental significance of findings needs context of roof setting in a particular watershed and fate and transport evaluations, 4) a number of onsite treatment options exist for roof runoff treatment and are well recognized including LID (e.g., rain gardens, swales) for urban and commercial buildings, and downspout filters for industrial buildings and these are proven for metals removal in the PNW (proprietary such as Stormfilter and home grown such as Grattix).	The abstract is limited to 300 words.
4	8	abstract	Tobiason	Windward Environmental	abstract should provide quantitative values and avoid qualitative terms such as "substantially elevated", "quite high".	Abstract has been revised to be more quantitative.
5	all	all	Tobiason	Windward Environmental	global: "new roofing" throughout could be construed as a brand new product on the regional market, or freshly installed material, which is the case, so you may want to check context and use better terms.	This has been defined in the Purpose section.
6	all	all	Tobiason	Windward Environmental	global: "in Puget Sound" is often used loosely and suggests other context, please check each usage for accuracy	This has also been defined in the Background section.
7	all	all	Tobiason	Windward Environmental	global: refrain from broad use of "toxics" and instead, replace with "chemicals" or " potentially toxic" since some of the metals are micronutrients and not always "toxic".	The terminology has been consistently used throughout the Puget Sound Toxics Assessment investigations and will remain consistent here.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
8	all	all	Tobiason	Windward Environmental	global: check misspelling copper as "cooper"	Corrections made.
9	all	all	Tobiason	Windward Environmental	global: replace "roof" with "panel", it is msot often the correct term	When talking about the pilot scale roofing panels, we have made changes to consistently refer to them as panels or roofing panels. When comparing our results to the literature, we have added designations to the tables to indicate whether the researcher was using panels or full-scale roofing systems.
10	8	abstract	Tobiason	Windward Environmental	may want to indicate the non-AR shingles had higher copper than expected, and include outcomes from XRF scan proposed in Nov meeting	Unfortunately, we are so limited on words that these finer points cannot be included.
11	8	abstract	Tobiason	Windward Environmental	Editorial: in second paragraph, rewrite the third sentence, the range values are provided and no need to be vague about what "reaching parts per million range" means.	This section has been re-written.
12	8	abstract	Tobiason	Windward Environmental	Editorial: third paragraph, in last sentence consider replacing ".contamination" with " blanks". Or "background levels found in laboratory blanks"	Wording has been changed.
13	8	abstract	Tobiason	Windward Environmental	last paragraph, in first sentence delete intro clause to let the results stand first, then qualify in an added sentence to the effect "However, the leaching method was aggressive and not representative of environmental exposures, thus the results were of limited value and this method is not recommended for future evaluations".	Wording has been changed.
14	9	acknowledgements	Tobiason	Windward Environmental	you might want to list all the other folks in the RTF, or just list RTF members and their roles	Good suggestion

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
15	12	intro	Tobiason	Windward Environmental	The first paragraph oversimplifies the apparent pathways and makes it sound like you are talking about Puget Sound water concentrations.	The words "contaminant releases" fairly clearly depicts that we are discussing releases from sources rather than what reaches the water bodies.
16	12	intro	Tobiason	Windward Environmental	Add a sentence at end of the first paragraph to the effect "In turn, the potential impacts of roofing source contaminants on receiving waters depends on a number of factors, which in turn need further assessments before potential environmental effects can be evaluated."	This entire section focuses on releases, as does the Literature Review. Addition of this sentence would send the reader off in a different direction.
17	12	overview	Tobiason	Windward Environmental	the overview starts off going back and forth with a lit review and the PSTLA motivator; third paragraph seems better in first position, followed immediately by "Puget Sound Basin Roofing Assessment" (please add " Need for a.. " to this title). Then move the first two paragraphs from under Overview into the new section " Literature Review " to begin on Pg 13 right before "Metal Roofs". This is where you want to begin roof lit review and start with generalized points.	Suggestion accepted.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
18	12	overview	Tobiason	Windward Environmental	embellish the PSTLA paragraph, it is too brief (and not truly a "study" which implies data collection). Please include a short discussion of the basis of the roof runoff estimates. For example, you should note that the PSTLA 'releases' were based on total area estimated for each of the roofing material types and the relative portion of each main type estimated to be in use in the greater Puget Sound area (e.g. PSTLA Appendix B, Tables B-1 and B-2). While copper roofing was tested, PSTLA estimated copper roofing comprised 0.3% of the total roofing area, "metal" was 5% while asphalt shingles were the vast majority at 71%. Need this info to put results in perspective.	A summary of the methods used in the PSTA study is not specifically relevant to the implementation of this study.
19	13	Puget Sound Basin Roofing Assessment	Tobiason	Windward Environmental	in the general discussion of various studies, consider briefly mentioning the other important key factors in interpreting results: specificity of materials tested, scale (built roof vs panels), age, sampling methods (grab vs composite), numbers of samples, sampling locations (drip edge vs downspout vs drains), blanks/QC, confounding effects of other roof sources (HVAC, cooling towers, gutters, flashing, etc), and how well these were documented in studies reviewed. Same comment for pages 76-77 comparisons to other studies.	The requested information more appropriately belongs in the Methods section of the report.
20	16	Table 1	Tobiason	Windward Environmental	Chang et al 2004 study results for zinc in all entries of Table 1 are prime example of confounding effects of study sampling location that included a galvanized gutter. You should point this out, it places significant doubt (high bias) on all zinc results from the Chang study, and helps add strength to your study design that prevented such.	Entries in the table state that the gutter was galvanized metal.

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21	12, 21, 22	overview	Tobiason	Windward Environmental	recommend deleting extraneous lit review sections that were not related to the PSTLA or specific areas of this study including roofing adhesives and vegetated roofs; while these attempt to add to the story, the significant content is not balanced by more important information that is missing as related to 1) fate/transport/treatment, and 2) other potential contaminant sources (HVAC, cooling towers, etc)	Comment noted.
22	13	metal roofs	Tobiason	Windward Environmental	text is often hard to tell what roofing material is being talked about or even if it is roofing material vs other metal component so make sure is clear, and consider splitting out with sub headers by major metal roofing material types (copper, galvanized, galvalume)	Some reorganization of the section has been done to improve the flow.
23	12 thru 25	lit review	Tobiason	Windward Environmental	General comment: a number of the literature summaries from pages 12-25 miss important points that are important to developing the understanding for this project. I provide some specifics below, but these illustrate a more thorough review is needed.	Additional literature review is beyond the scope of this study.
24	13	metal roofs	Tobiason	Windward Environmental	1st paragraph, add that zinc roofs are common in Europe and very uncommon in the US in general. The text shouldn't conflate pure zinc roofing with galvalume/zincalume coated steel and galvanized steel materials.	A statement has been added to the beginning of the Metal Roofs section indicating that galvanized roofs are more common in the US.
25	14	metal roofs	Tobiason	Windward Environmental	3rd paragraph overgeneralizes that PSTLA used all data contained in Table 1, it used some but not all.	Reference to Table 1 in that sentence was removed to prevent implication that the PSTA study used the values in Table 1.
26	14	metal roofs	Tobiason	Windward Environmental	4th paragraph discusses things other than metals, keep it focused and move general stuff up higher under generalized roof issues.	Paragraph moved.

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27	14	metal roofs	Tobiason	Windward Environmental	5th paragraph: Thankyou for including mention of the SeaTac Galvalume study (Tobiason 2004). However, it bears further mention than a single sentence. It was a relevant study from the region and so earlier statements indicating lack of regional data need to be corrected (page 13).	Additional wording has been added.
28	14	metal roofs	Tobiason	Windward Environmental	5th paragraph, second half talks about brass and Cu-Zn alloys, sounds unusual, is it relevant? Can you mention what roofing products the Brunk et al 2009 and Herting et al 2008 studies tested and if they are relevant to the US or our area?	This discussion goes to the point that alloys do not necessarily release metals in proportion to their composition. This may be true as zinc alloys are proposed for roofing materials in the US and elsewhere.
29	14	metal roofs	Tobiason	Windward Environmental	6th paragraph bears mentioning of pre/post zinc leaching study at SeaTac to evaluate painting of roofing (and guardrails, etc), see Taylor Associates 2004 and Tobiason et al 2006, which I provided in 2012.	This paragraph has been divided into two paragraphs and now includes Taylor's and Tobiason's work.
30	14	metal roofs	Tobiason	Windward Environmental	6th paragraph conflates Al-Zn metal coatings with composition of paints and other non-metalcoatings, you should check with Steelscape on this.	This paragraph has been divided into two paragraphs and now includes Taylor's and Tobiason's work.
31	15	Table 1	Tobiason	Windward Environmental	Please add a column indicating whether each study was panel scale or a full built roof on a building (as much as possible). Scale is very important in determining rainfall contact time as related to leaching. You cite a lot on Clark 2010 results, they were panel scale and quite a bit different among certain materials when compared to full scale studies. Chang 2004 is another panel study and I would recommend either deleting the Zn results or adding a note accordingly (and as noted above was flawed because it used galvanized gutters to collect runoff from each of 4 material types).	The recommended column has been added to the tables in the Discussion section, where the issue of scale is more relevant, rather than into Table 1.

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32	14, 15	metal roofs, Table 1	Tobiason	Windward Environmental	delete "steady state" in text and Table 1 title sub head, no such thing in this context here.	Wording has been changed to "post-first flush"
33	15	Table 1	Tobiason	Windward Environmental	You may want to move Table 1 into an appendix and add your study data to date to this table as you presented in the nice tables at the November meeting. I think it is very important to compare your findings with others.	Table 1 needs to be located near the text which continues to reference it.
34	15	Table 1	Tobiason	Windward Environmental	thanks for segregating Table 1 better by material types from the version in the prelim report last summer. Consider further splitting Galvalume and coated steel data sets, these are distinctly different (hi/low). Thanks also for including the correct data for the SeaTac Galvalume study (Tobiason 2004).	Comment noted.
35	15	Table 1	Tobiason	Windward Environmental	Good 1993 results you listed were as reported for sample #2 of roof #2 "weathered metal, may have been coated with aluminum paint..". Good indicated roof #1 was more clearly "rusty galvanized metal". So may want to state more clearly the basis of the numbers you list, or list both sets of results (the table lists multiple results from several other studies).	The roof description indicates that the metal roof was weathered and potentially painted. Only the second-round sample was used from Good's work, as Table 1 presents post-first flush results only.
36	15	Table 1	Tobiason	Windward Environmental	ND is not explained in table footnotes, presumably non-detected, also, would be more appropriate to replace "ND" with "<[value]" as much as possible.	Where the literature provided detection limits they were included in the table. ND is often used in the literature rather than a quantified value. ND has been defined at the bottom of the table.

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37	15	Table 1	Tobiason	Windward Environmental	check year 2000 for Mendez, shows up as 2010 later and in refs. May also want to cite Mendez' 2010 Water Research journal article. Mendez tested panels and whole roofs and in 3 different sample types from the panels so results should be segregated and/or explained in Table 1 accordingly. You appear to list only Mendez' "tank 2" results and omit their first flush and tank 1 results without consideration.	Correction made to date of Mendez's work. Only the tank two samples were represented, as Table 1 presents post-first-flush results only.
38	16	Table 1	Tobiason	Windward Environmental	add Bielmeyer 2011 to copper roof study group. Scale tested was a "trough" which seems generally comparable to a "panel". Later in report you cite this study.	Bielmyer's work more appropriately belongs in the discussion of residence time.
39	18	Table 1	Tobiason	Windward Environmental	In citing roofing Felt from Clark 2010, why is this included? It is not intended as an exposed finished roofing material, so please add a qualifying note or delete. Also in the related text on page 20 about these results, you should state that the results are of limited value since related to typically unexposed material.	Roofing felt was deleted from Table 1, but is mentioned in the text with a disclaimer.
40	18	Table 1	Tobiason	Windward Environmental	CCA needs definition (table footnote). If possible, check studies and specify what "wood" meant (shake/shingle/ply or whatever), and what treatment products were used in the "treated" and "impregnated" specimens. If this info not available, then make a note of it in table.	Where the information was available in the literature, it was added to the table. CCA was defined in the footnotes.
41	19	Non-Metal Roofs	Tobiason	Windward Environmental	delete this section title and use of "non-metal" elsewhere in text since there is no forgone discrimination between metal and non-metal roofing. Just use section headers for each specific material type: tile, asphalt shingles, plastic/single ply and BUR.	Title changed.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
42	19	Non-Metal Roofs	Tobiason	Windward Environmental	Many studies had only a handful of samples or less so be careful of overgeneralizing about a particular roof type (e.g. copper from 1 sample from BUR in Good 1993).	Clarifying language was added here.
43	19	Non-Metal Roofs	Tobiason	Windward Environmental	"asphalt" should be clear each usage whether "asphalt shingle" or asphalt/tar in BURs	Clarification provided.
44	20	Non-Metal Roofs	Tobiason	Windward Environmental	Consider qualifying the Mahler et al 2012 citation as "Although not a roofing material study, Mahler's study of road surface sealants suggests the type of biumimous materials used in BURs may be an important consideration". Mahler et al PAH studies have come under scrutiny recently and you may want to check latest context.	The prepositional phrase "In a study of road surface sealants" alerts reader to the fact that this was not a roofing study.
45	20	Non-Metal Roofs	Tobiason	Windward Environmental	Need to explain relevance of "exposed plastic sheeting" (Patuska 1985), it doesn't sound like a robust finished roofing material. How does it and the gravel/mud relate to roofing lit review?	While this study is written in English, it is clear that common usages of words are different. I assume this is corrugated PVC. The author talks about PVC sheeting as fixed on a foundation, so one must assume that it is a long-term material.
46	20	Non-Metal Roofs	Tobiason	Windward Environmental	discussion on BEHP lit results should talk about likelihood of high bias due to typical sample/lab contamination encountered.	Researchers likely qualify results when laboratory contaminants such as DEHP can affect results. For example, Pitts' (2000) paper specifically indicates that DEHP was much higher in the plywood than in the other materials.
47	20	Preservatives in Roofing	Tobiason	Windward Environmental	why are results for "untreated" materials discussed? Are you suggesting labeling problems or some kind of background? Are the results even worth mentioning? Clark 2010 untreated wood results were mostly negative, Khan had only arsenic data.	Untreated wood is mentioned by way of comparison.

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48	23	pH	Tobiason	Windward Environmental	Misspelling of "Odenvall" should read "Odnevall", check global. May also want to mention the Wallinder copper model associated with her work since it is highly published.	Spelling corrected.
49	23	rainfall intensity	Tobiason	Windward Environmental	1st paragraph, second half is about dissolved metals, doesn't fit this section header. Suggest a separate section on dissolved metal fractions found in roof runoff.	This paragraph moved to a new section.
50	24	residence time	Tobiason	Windward Environmental	good points, consider mentioning residence time is also proportional to study scale, e.g panels vs full scale built roofs. Consider also noting the substantial difference in Zn between full roof and panel studies also suggests residence time/travel length plays an important role for galvanized and Galvalume materials. You see this in comparing Table 1 and this studies results (ZIN).	A sentence has been added in this section to bring that point home. In the Discussion section, the point will be revisited.
51	24	residence time	Tobiason	Windward Environmental	Consider adding that Bielmyer et al 2011 also found orientation and slope were not as important as travel length in determining copper in their scaled study. Also, Bielmyer et al correct year is 2011, not 2012 as written on p. 24. In the last sentence, also replace "panel" with "experimental trough" which was a 16" wide x 30 ft long copper "trough". Change "rain drops" to "synthetic precipitation runoff" to be clear.	Changes made.
52	24	orientation	Tobiason	Windward Environmental	consider adding that Bielmyer et al 2011 found orientation and slope were not as important as travel length in determining copper in their scaled study.	A sentence was added to that effect.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
53	24	aerial deposition	Tobiason	Windward Environmental	since discussion of atmos dep has not been limited to roof runoff, consider mentioning SeaTac zinc results from Taylor Assoc 2004: three samples had TR Zn at 80, 113 and 157 µg/L in SPLP spray water runoff from simulated plastic guardrail near airport freeway	Comment noted.
54	26	Purpose	Tobiason	Windward Environmental	Editorial: Ecology 2011a is referred to in this report using several different names, consider consistent and abbreviation (i.e. PSTLA).	The Puget Sound Toxics Assessment (PSTA) is now consistently used.
55	28	methods	Tobiason	Windward Environmental	2nd par: explain why leachate from coated metal roofing coupons was tested for organics that wouldn't be expected from the metal material itself	The explanation is provided in the SPLP subsection of the Methods with other details rather than in the Summary on page 28.
56	28	methods	Tobiason	Windward Environmental	2nd par: correct text to reflect the three metal roofing materials tested: ZIN, CPR and galvanized steel (not simply "copper and zinc". Since uncoated/unpainted galvanized steel wasn't tested at panel scale, you may want to explain why coupons were tested and not panels for this material	Change made.
57	28	XRF methods	Tobiason	Windward Environmental	2nd par: xray penetration depth range seems to suggest XRF results are integrated across a considerable material depth and may not represent what is exposed to rainfall, so please address this point. On page 38 XRF results, the 3rd bullet in exceptions hints at this for chrome. So think about stating some limitations in how XRF results should be used.	A sentence was added to the XRF Methods section.
58	29	Table 2	Tobiason	Windward Environmental	for the AAR and AS note that Appx A indicates one supplier had only 2 courses of shingles installed while the other 5 had 3 courses.	This more appropriately belongs in Appendix A and has been added.

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59	29	Pilot Scale...	Tobiason	Windward Environmental	consider adding the rationale for AS replicates was also intended to represent the wide array of variables as suppliers indicated includes mineral source, asphalt source, and manufacturer. Was there any randomization in relative location of each product on each panel? This may help relate the one rep with higher Cu than others.	Language has been added. The subsequent discussion will deal with the higher copper from AS-3.
60	30	Pilot Scale...	Tobiason	Windward Environmental	top of page 30, add the different usage rates for AS and AAR shingles in our area. Believe PSTLA said 71% of Puget Sound roofing area was asphalt shingle, but it didn't discriminate AS from AAR usage, so it would be helpful to know the relative fractions.	The relative fractions of AAR and AS were not investigated for the PSTA study. A qualitative statement was added to the discussion of the asphalt shingle replicates.
61	30	Figure 1	Tobiason	Windward Environmental	great photo, add note under it for rain gage location in photo	Change made.
62	31	sample collection	Tobiason	Windward Environmental	Which sample events/panels had sample collection ceased before runoff stopped? Covered in results? Table 11 doesn't indicate.	This information can be found by evaluating the rain gage data which were added as part of Appendix C. Also, this information does not belong in the Methods section.
63	31, 35, 36	sample collection	Tobiason	Windward Environmental	"split samples" procedure used wouldn't generate a true field sample replicate, as also commented in the QAPP review. These splits have limited QC utility (they are pretty much like a lab split). Were any results rejected based on split RPDs?	This section has been rewritten to separate the RSDs for the splits from those of the replicates.
64	32	SPLP	Tobiason	Windward Environmental	describe who applied the coatings, and if methods, thickness etc met coating mfg recommendations.	As noted in the text, the details are provided in Appendix B.

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65	32	SPLP	Tobiason	Windward Environmental	Add SPLP method ref EPA 1312 (that's the one right?) and clarify that SPLP wasn't designed for this application. Complete submergence in a volume equal to annual rainfall plus the tumbling procedure is highly questionable in testing roofing material coupons. The discussion section should talk about the limitations of this method.	Method number added. The Discussion section discusses these limitations.
66	32	SPLP	Tobiason	Windward Environmental	please specify the pH of the SPLP leachant reagent used and any other relevant chemistry details (alkalinity, ionic strength, etc).	The details of the SPLP portion of the study are provided in Appendix B.
67	32	SPLP	Tobiason	Windward Environmental	explain in text and add Table 3 footnote that galvanized steel as tested in coupons was not tested in panels	Changes made.
68	34	Field QC	Tobiason	Windward Environmental	It would be helpful to list MDLs and RLs in report body for easy reference, i.e. Table 4, and in footnotes to the various tables and figures so reader doesn't have to dig up from the QAPP.	The document is already over 100 pages, referencing the QA Project Plan is an acceptable way to manage the document length.
69	35	field QC Table 6	Tobiason	Windward Environmental	Table 6 shows eqpt rinse blank and DI water blanks were collected only once each, yet text above Table 6 says these rinse blanks were collected each event.	Table 6 shows only those samples that were used for field splits and matrix spike/matrix spike duplicates, not the equipment rinse or the distilled water blanks.
70	35	field QC	Tobiason	Windward Environmental	where are eqpt rinse blank data? These should be provided in results and discussed, I don't find them in Appx D tables.	These data are provided in Appendices E and F for those who are interested in reviewing the data. Where the results of the equipment rinse blanks showed contamination, the results from the roofing panels were managed as described in the text.

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71	35	data qualifiers	Tobiason	Windward Environmental	Although the CPR Cu values were J-flagged high values, the reported concentrations were used in calculations and reported in summary tables and plots (i.e, without further qualifiers). The basis of these J qualification is unusual because it was not provided by the lab, but based on author QC review, apparently because the MSD spikes exceeded the RPD acceptance criteria, apparently due to spiking amounts that were too low in comparison to the sample value. Please point this out.	You are correct in your assessment that the rationale for an M qualifier in Appendix F indicates that both the MS and MSD RPD exceeded those specified in the QA Project Plan. The report will not provide that level of detail.
72	37	variability	Tobiason	Windward Environmental	Text is lumping splits and reps in discussion; if field splits are pairs of results, then should be RPDs. True field replication was only achieved for the three non-AR panels and these reflect both sampling variability and material variability (given composite of 6 different products)..	This section has been re-written to separate the RSDs for the splits from those of the replicates.
73	37	variability	Tobiason	Windward Environmental	Editorial: you could also say sampling bias was minimized by your sampling scheme of collecting 100% of the runoff, and sub-sampling error was minimized by mixing before pumping aliquots into sample containers. Also, variability was "among" (not "between") storm "samples".	This section has been re-written.
74	37	summing organics	Tobiason	Windward Environmental	could you say that the organics results were so low anyway that the other methods of handling non detects wouldn't tend to improve the distinction among products and that any one was a concern?	Thank you for this suggestion.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
75	38	results	Tobiason	Windward Environmental	It would be interesting to add a brief narrative on edge effects and what installers did (or didnt) do to prevent issues and what Ecology observers noted. Did runoff tend to cascade directly into gutters or did some materials tend to entrain runoff under the drip edge? What drip edge installation details could have affected results? Consider that TWO and WOS probably had end grain wood exposed. How well sealed were the various drip edges to prevent contact with underlayment or cut edges of metal roofing? Did much runoff flow off the long edges and not make it into the gutters?	A bulleted narrative of observations has been added.
76	38, 44	XRF results, field data	Tobiason	Windward Environmental	Global: a bit loose with "samples" and "roof", replace with "coupon" and "panel" consistently	Wording changes made to provide greater clarity.
77	38	XRF results	Tobiason	Windward Environmental	XRF results seem to indicate enough differences between coupons and panels that last sentences will be questioned so may want to consider a more cautious statement than last sentence. It doesn't appear that the XRF results were used to accept/reject any of the materials but only to characterize.	The outlier for copper in the asphalt shingle coupon without AR has been removed from the table. Rationale has been added for bromine in the TPO coupon. Some wording changes have been made to the final sentence.
78	38	XRF results	Tobiason	Windward Environmental	thrid bullet reads 3 types of painted galv coupons, but only two tested (silicone was on PAZ, right?)	Three types of painted galvanized steel coupons were tested. Edited test bullet and Table 7 to remove reference to the panel types to remove confusion.
79	38	XRF results	Tobiason	Windward Environmental	first bullet suggests a discrepancy in controlling copper in AR and non-AR products, what was resolution? Do the non-AR panel copper results tend to also suggest an issue since 1 rep was reportedly higher than the other 2?	Despite our best efforts, the manufacture did not get back to us, and this was not resolved. Thus, the extremely high copper concentration was eliminated from Table 7, and a narrative explanation of manufacturing variability provided.

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80	38	XRF results	Tobiason	Windward Environmental	seems like some more exceptions to add to the bullet list: no arsenic in PVC coupon but got arsenic hit in PVC panel. Got reverse for arsenic in TPO. Tables 7-8 show cadmium and copper ranges were different between a number of coupons and panels. If you are considering the differences insignificant, then probably want to back that up with something about limitations/precision of XRF.	The exceptions were reassessed and some more exceptions added.
81	39-40	Table 7 and Table 8	Tobiason	Windward Environmental	consider consolidating Tables 7 and 8 so side by side comparisons are easier where coupons and panels of same material tested.	We felt it important to include the Tables 7 and 8 in the main document. Ecology rules for table size and font size do not allow side by side presentation.
82	39-40	Table 7 and Table 8	Tobiason	Windward Environmental	Consider that the PAZ coupons and panel Zn results were >> than the ZIN coupons and panel results which is counterintuitive given the paint film on PAZ and exposed zinc content on ZIN surface. Need to discuss and relate to XRF penetration depth (see comment above).	PAZ is galvanized metal underlying the paint. The ZIN coupons and panel are made of a zinc and aluminum alloy. One would expect PAZ Zn concentrations to be much higher.
83	39	Table 7	Tobiason	Windward Environmental	some of the copper results ranges appear reversed, i.e. not all are min-max, some are max-min or max is missing digits?	Corrections made to values in Tables 7 and 8.
84	36	Laboratory contaminants	Tobiason	Windward Environmental	It is unclear how a less sensitive method would help distinguish between comparable, low-level concentrations of total PAHs. Use of less sensitive analytical method would provide less insight into contribution of tested materials to total PAHs in runoff, and it is unclear why that would be desirable.	Clarification added.
85	34	Table 4	Tobiason	Windward Environmental	PAHs and phthalates analytical method should reference "Selective Ion Monitoring", not "Single Ion Method"	Correction made.

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86	41	rain events	Tobiason	Windward Environmental	need to distinguish rain event duration from sampling event duration since sampling sometimes stopped before rainfall ceased as indicated in methods. Which events had sample collection ceased before rain ended and what was total rainfall at that time?	Narrative has been added to the text. However, please note that rain-event starts and stops in the Pacific Northwest can be nebulous— unlike in other parts of the country. The rain gage data have been added to Appendix C for the commenter's further assessment.
87	41	rain events	Tobiason	Windward Environmental	placing sample containers (open pots) prior to rainfall beginning may raise question of how long and potential for atmospheric dep?	The pots were under cover (under the "umbrella boxes"), so no atmospheric deposition accumulated in the pots.
88	41	rain events	Tobiason	Windward Environmental	provide brief example for second avg rain intensity metric, its not clear from text how it was calculated	Clarification added.
89	42	rain events	Tobiason	Windward Environmental	Explain why mentioning SOx data (e.g. acid precip). But data from Seattle would be generally downwind of site and of limited value (?). What if any historical SOx data are available upwind? Maybe wrong here, but isn't the Centralia coal fired power plant a suspect for some potential regional acid rain?	This was requested by one of the members of the RTF in one of the meetings (presumably from a location where sulfur dioxide concentrations are higher). The data provided were the only data available for the area.
90	43	Figure 2	Tobiason	Windward Environmental	this is a rainfall hyetograph, not hydrograph (open channel flow), and is best plotted as bar chart not continuous line. Seems like any events should be indicated where sample collection ceased before rainfall ceased.	Terminology changed and plot type changed.
91	44	field data	Tobiason	Windward Environmental	Editorial: picky here, but specific conductance (you may want to use "SpCond", not "specific conductivity") would be less expected to change over holding time since SpCond is a temperature-normalized value by definition already (conductivity would definitely change as a function of temp).	Terminology changed.

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92	44	field data	Tobiason	Windward Environmental	The pH and SpCond results are glossed over and not covered in the Discussion section. There are some interesting findings to report (see next comment). Some more analysis of pH and SpCond data would be helpful, can you run stat tests for differences? Consider adding box plots for pH and SpCond to help interpret results better than Table 19, to show which materials tended to alter pH and SpCond and which were similar to the glass controls. Materials that would tend to increase pH over controls would tend to be a positive effect (although the benefits could depend on relative toxicity of ions elevating the pH).	pH and specific conductance are not the major focus of this report. While your analyses are appreciated, such analysis goes beyond the scope and the time allotted for the report.
93	44	field data	Tobiason	Windward Environmental	Should note that CTI had much higher pH and SpCond than other materials, likely associated with alkalinity imparted by the concrete matrix. See similar tile results for pH in Mendez 2010. In contrast, WOS had highest SpCond but lowest overall pH which indicates something else going on. Also appears CTI had SpCond pattern decreasing with rainfall like As, Cu, Zn did for other panels, see plots in tabs added to this file. If the first event SpCond is excluded the R ² values improve quite a bit (could the meter have been off in first event?)	Potential causes for the differences in the pH and SpCond of the CTI and WOS panels have been added. See also response to previous comment.
94	44	field data	Tobiason	Windward Environmental	temperature data are probably more useful for looking at QC and field preservation during sampling. With the QAPP's goal of maintaining <6°C before analysis, what do the higher sample temps indicate for potential QC concerns?	The temperature requirements for preservation apply to the samples after they are collected and until they are analyzed. All the samples reached the lab within the temperature equipments. The ice baths surrounding the containers were an attempt to keep the samples closer to ambient temperatures, rather than

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						heating up in the umbrella boxes when the sun was out.
95	45	Table 10, Appx D Table 5	Tobiason	Windward Environmental	zero values for specific conductance should be replaced with a measured value	The measured values were zero on the meter used.
96	46	Table 11	Tobiason	Windward Environmental	add a column for event date and note whether total precip was over sampling period or "event" to indicate which samples ended before rain ended.	Narrative has been added to the text in the Rain Events section indicating specific events that were stopped. However, please note that rain events starts and stops in the Pacific Northwest can be nebulous— unlike in other parts of the country. The rain gage data will be added to an appendix for the commenter's further assessment.
97	46	Table 11	Tobiason	Windward Environmental	event 7 sample volumes appear to be lower than the event rainfall would predict when plotting rainfall vs sample volume, was sample collection ceased before end of rainfall? If not, it could suggest rainfall measurement or volume measurement were off and need consideration later when evaluated.	Precipitation amount was reported only for the period of time during which the collection system was in place. We did not assess the amount of precipitation following disengagement of the gutters.
98	46	table 11	Tobiason	Windward Environmental	add a statistical measure of variability among the sample volumes collected such as the CV, this would be more meaningful than the min/median/max values provided.	This is not critical to the focus of the report.

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99	47	Figures 4-8	Tobiason	Windward Environmental	nice figures! Arsenic and copper scales skip log cycles at 1.0 and 100 adding these would help distinguish certain results. Also, the beginning y-axis scale values are not specified, so the non-detects lose some order of magnitude perspective	We looked at this, but the figures become too messy by adding additional grid lines, and the reader loses the visual effect of the figures.
100	47	Figures 4-8	Tobiason	Windward Environmental	wondering if material types can be less cryptic than 3 letter codes, requires a lot of paging back to Table 2, same thing for Table headers.	We agree this would be easier for the reader. However, everything else we tried became unwieldy. We cited the page number where the definitions can be found to the bottom of each table and figure.
101	47	Figures 4-8	Tobiason	Windward Environmental	consider adding footnote reminding the reader that the AS results in each figure are average of 3 panel reps.	A note has been added to the narrative.
102	52, 55	PAHs, phthalates	Tobiason	Windward Environmental	probably want to state a reference for the contamination thresholds at 5X method and eqpt blanks. The 5X basis isn't mentioned under phthalates, and you may want to say all results were J-flagged (at least as they appear in Table 15) and the basis (<RL?) or other reason to J-flag?.	The QA Project Plan has been added as a reference. The detailed rationale for the qualifiers is provided in Appendix F. All of the detailed qualifiers were rolled up to J values as described in the Data Qualifiers section.
103	58	PBDES	Tobiason	Windward Environmental	in first sentences, replace "measured" with "analyzed", as it infers 100% detection, which was not the case. Looks like somewhat comparable results between TPO and EPDM, even though TPO showed a bigger bromine hit in XRF coupon, so panel PBDEs and panel XRF each suggest fire retardants absent (?)	Change made. See also pers. comm. from Hubbard about TPO provided not having flame retardant in the Results XRF section.

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104	60	SPLP Analysis	Tobiason	Windward Environmental	Confusing between "rounds" and "replicates" and which groups of coupons are being discussed. Clarify if Table 19 are results from the second "round" since Appx D has data for 1st and 2nd "rounds". Was second round what was "repeated without filtration"? QAPP didn't call for multiple rounds or filtration.	Clarification has been added to this unanticipated need for a second leaching, because the first leaching was so highly contaminated.
105	60	SPLP Analysis	Tobiason	Windward Environmental	text makes it sounds like all of the zinc results for the 01 and 02 reps for each coupon are high biased and should not be included. Would be helpful to disclose method blank results for all the metals, not just zinc. In looking at Table 47 in Appx D, the Zn results were higher in round 2 than round 1, how can that be explained or just too many variables inherent in the SPLP method?	Results are likely higher in Round 2 than one because of the second exposure to the acid. Only Round 2 data were compared to one another to ensure comparability among the coating types.
106	60	SPLP Analysis	Tobiason	Windward Environmental	what filters were contaminated? Data in Table 19 are for total Zn which didn't require filtration. I don't see filtration mentioned in the SPLP method described in the report nor in the QAPP.	The SPLP method calls for grinding of the samples and filtration of the leachate to prevent the particulates from being analyzed. As described in the QA Project Plan, we did not grind the coupons. In Round 1 the lab tech filtered the samples, as specified in the method, which lead to the contamination. The Round 2 leachate was decanted.
107	60, 61	SPLP Analysis, Table 19	Tobiason	Windward Environmental	Comparing SPLP zinc results between Zinalume and galvanized isnt really a relevant "reduction" since Zinalume is an alternative to pure zinc galvanic coating, not something like the other after market products that would go over Zinalume. If you keep it, indicate in table that average % reduction for Zinalume is based on uncoated galv steel.	A footnote has been added to the table.

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108	62	SPLP-organics	Tobiason	Windward Environmental	consider saying that about 1/3 of the PAH detections were J-flagged so that magnitude of "detections" was relatively low and probably insignificant.	The note has been added to the narrative. We do not consider the detections insignificant.
109	62	SPLP-organics	Tobiason	Windward Environmental	why was only one coating material tested for PBDEs, was it because they were a known additive to this coating and not suspected in all the others?	According to the RTF coatings specialist, PBDEs were thought to be in this coating, as now described in the Methods section.
110	64	discussion	Tobiason	Windward Environmental	add discussion of pH and SpCond results, as mentioned under field data the results bear some thought	pH and specific conductance are not the major focus of this report. Suggested detailed analysis goes beyond the scope and the time allotted for the report.
111	64	rain event information	Tobiason	Windward Environmental	2nd par, next to last sentence is a bit incorrect since storms #9 and #10 had higher pH in GST control than any other event, storm #9 had highest pH in GLO.	As specified in the Field Data section of the Results, the pH meter drifted during Event 9. The data from Event 9 were not used to calculate the medians provided in Table 10. Based on a re-evaluation of the data in Appendix D, the sentence has been changed.
112	64	volumes recovered	Tobiason	Windward Environmental	were steep slope panel areas corrected for angle in volume calcs? If not, that might explain >100% recoveries.	Yes, the projected surface areas were calculated.
113	66	total metals	Tobiason	Windward Environmental	2nd par, first sentence is just another example of loosely used "roof", in this case a better word is "boxplot"	Change made.
114	66	arsenic	Tobiason	Windward Environmental	the 1 and 3 µg/L levels mentioned seem a bit arbitrary, if there is some other significance to these numbers mention it, or if not could just say only the TWO and PVC were greater than controls. Also, third paragraph needs "TWO" in the first sentence.	Sentence has been slightly modified.

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115	67	cadmium	Tobiason	Windward Environmental	a boxplot for cadmium should be included since the text makes relevant comparisons requiring flipping back to Figure 5.	The box plot was deemed unnecessary, as most of the values are less than the MDL. Where figures from the Results are mentioned, their page numbers will be provided to make maneuvering through the document easier.
116	67	cadmium	Tobiason	Windward Environmental	Since are same slope family and paired sample events, why cant TWO and GST Cd results be tested by Wilcoxon? Text on page 66 explaining Wilcoxon seems to apply.	Comparisons have been added for both TWO and CPR.
117	67	boxplots	Tobiason	Windward Environmental	use more customary log scale on boxplots: add tick marks for major divisions and delete the 5x log cycle labels.	While not customary, the 5x log ticks do not detract from the graphs and may help the readers.
118	67	boxplots	Tobiason	Windward Environmental	in all boxplots, the superscript "A" following "AS" isnt defined, and presumably relates to needing to explain these results were the average of the 3 replicate panels of this material.	The superscript has been defined in the narrative and has been consistently defined in each table footnote throughout the report.
119	68	copper	Tobiason	Windward Environmental	end of 1st and 2nd paragraphs separately compare two panels to controls, suggest keeping these 4 together. You may also want to say the difference between AAR and AS was expected to be associated with copper granules, although AS was still above controls.	A statistical analysis comparing the copper in the three AS panels was added along with the findings of the additional XRF analysis. The time-release copper granules on the AAR panel have been added in this discussion.
120	69	lead	Tobiason	Windward Environmental	like for arsenic comment above, the 1.2 µg/L as a significant value to base discussions on is arbitrary.	Change made.

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121	69	lead	Tobiason	Windward Environmental	while Pb was low here, both glass control results for lead suggest they had a relative source of lead since as you say were "greater than runoff from a number of roofing types". Or could this suggest atmos dep Pb sorption by some roofing materials? Consider mineral particles present in AAR, AS, and BU panels could be sorbents.	Some potential reason for higher concentrations of lead on the glass control compared with TWO have been added.
122	70	zinc	Tobiason	Windward Environmental	this is the first instance of comparing results to PSTLA, so to be even, either do the same for the other metals or save it for the page 76-77 separate section.	The paragraph has been moved to the subsequent discussion of PSTA.
123	70	zinc	Tobiason	Windward Environmental	1st paragraph: as per earlier comment, lower Zn from ZIN most likely due to panel scale effect, which is also evident in the Table 1 study comparisons between full scale and panel scale. While it's possible that other roofing components could explain elevated Zn from some full roof studies, there is no basis for the second implication about galvanized metal roofing contributions so delete it.	Comparison with other roofing studies has been moved and the issue of scale has been added.
124	70	zinc	Tobiason	Windward Environmental	PAZ installation in Appx A says hot dip galv fasteners used, please address whether these could explain Zn in addition to unpainted drip edge of PAZ panel.	Since the fasteners are painted with the same paint as the panel (described in Appendix A), this is unlikely.
125	70	zinc	Tobiason	Windward Environmental	Fisler ref not listed in reference section	Added, thank you for your attention to detail.
126	71	total metals	Tobiason	Windward Environmental	clarify the glass control subtraction was based on paired sample results or based on median panel minus the median glass	Clarification provided.

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127	71	total metals	Tobiason	Windward Environmental	add a section title to separate "total metals" paragraph from following paragraphs where you are normalizing to rainfall and unit area (although I think these are off track as commented below)	The referenced paragraph was removed.
128	71	total metals	Tobiason	Windward Environmental	replace "standardize" with "normalize"	Paragraph was removed.
129	71	total metals	Tobiason	Windward Environmental	Providing the rainfall-normalized concentration values implies increasing concentrations with increasing rainfall, which isn't the case with the negative slopes in the figures 13, 14 and 15 for As, Cu and Zn (assuming the correlations are statistically significant). See added tab "T6 Cu" in this file that shows Fig 14 copper compared with values for CPR and TWO projected by Table 24 normalized values (the runoff concentration dependence on rainfall depth gets lost in a median of 10 data points). Since the correlations appear relatively strong, consider deleting the normalization approach and instead stress the more important empirical observations from Figures 13-15 (which others have observed). These appear to be a more appropriate basis for further evaluations such as for fate, transport and treatment needs. Another reason to delete Table 24 is that you are also saying elsewhere in the report that only certain materials generated significant concentrations of certain chemicals and Table 24 could be misused in projecting significant levels that were not found in this study.	Ecology concurs. The paragraph and Table 24 have been removed. The equations have been added to Figures 13 through 15.

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130	73	total metals	Tobiason	Windward Environmental	consider deleting Table 25 and last paragraph this section, it doesn't appear to add value, the units appear incorrect, and it sounds like a math exercise incorporating measurement error. The quantities and units cancel out and reduce back to concentration. Loads varied and were not constant per unit area as the table 25 values infer. See attached figures.	We calculated the median loads (releases) for our rain events and panels. While concentration does decrease with increasing precipitation (volume collected serving as a surrogate), our rain event precipitation depth ranged from the 52%ile upwards. Therefore, the release rates calculated may actually underestimate mass released per square meter. Caveats to that effect have been added to the text.
131	73	(mass loads)	Tobiason	Windward Environmental	Consider adding some text and figures for mass load, see examples I'm providing in "T6 Cu" tab this file. Mass load varied and was not a constant per unit area basis. However, mass loads for results that are mostly dissolved fractions are relatively meaningless where exposure concentrations would be more meaningful (and require transport and fate assessment)	See previous comment.
132	73	impacts of precip amount	Tobiason	Windward Environmental	delete "slight" and replace with "significant" and provide a statistical basis.	Wording has been changed in this paragraph.
133	73	impacts of precip amount	Tobiason	Windward Environmental	identify the curve fit types used in correlation plots figures 13-15, correlation coefficients are a function of curve fit type.	Both r ² and curve equations have been added to the figures. Narrative describes the relationship type.
134	73	impacts of precip amount	Tobiason	Windward Environmental	also indicate whether precip depth used for Fig 13-15 is for the total event or up to sampling cessation if gutters removed to prevent sample overflow	All rain depths used throughout the document are the rain gage measurements while the gutters were in place and sample being collected in the 15-gallon pots.

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135	73	impacts of precip amount	Tobiason	Windward Environmental	can also see the first flush/dilution effect when plotting copper from the CPR and zinc from the ZIN against sample volume collected, showing significant negative correlations	Agreed.
136	75	impacts of precip amount	Tobiason	Windward Environmental	Need to back up correlation evaluations with stats as to what methods used and what correlation coefficients considered "significant" or not. Given the relatively rich data set, consider providing a simple table of correlation coefficients and p values among the various factors rather than dismissing as "no correlations"	The simple regression performed in Excel resulted in inverse log normal relationships with r2 values provided in the figures. The narrative has been changed to describe this.
137	76	total metals compared to other studies	Tobiason	Windward Environmental	The comparisons among studies feels a bit cherry picked and a number of studies in Table 1 are not mentioned. Consider adding the tables that you shared at the 11/13 presentation (pages 42-49) that compared study results from each material to the respective groups in Table 1, would provide helpful apples to apples comparisons.	This section has been expanded with tables for the various roofing materials, making the most relevant comparisons with the studies in Table 1.
138	76	total metals compared to other studies	Tobiason	Windward Environmental	In comparisons note whether the other study was panel or whole roof or some other scale. Add that the Clark and Chang studies are most comparable because they too were panel studies (not whole roofs subject to scale factor and other potential sources). In this section pay particular attention to edits needed to correct "roof" to "panel" so the comparisons are clear among the study types. Again for Chang 2004 you should note the galvanized gutters present a flawed study design because can't separate Zn from roofing material and gutter.	This has been indicated in the tables that have been added.

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139	76	total metals compared to other studies	Tobiason	Windward Environmental	SeaTac Galvalume study comparison is missing (Tobiason 2004, Taylor 2004), please include this comparison to your results (whole roof vs panels). See attached tab with SeaTac data and plots comparing Zn and Cu with your study results.	The Tobiason study has been added to the tables and text. The Taylor study was added to the text, but not to the table, as the materials he tested were not tested prior to post-manufacturer-painting.
140	76	total metals compared to other studies	Tobiason	Windward Environmental	second bullet "since" appears to be typo, should be "zinc"?	Correction made.
141	76	total metals compared to other studies	Tobiason	Windward Environmental	5th bullet reference to AS superscript "A" needs a footnote to explain and Table 26 needs "A" superscript added to AS	This has been added.
142	76	total metals compared to other studies	Tobiason	Windward Environmental	5th bullet: Clark's data in Table 1 not indicated for AR shingles just "asphalt shingles" (fix Table 1?). The last sentence referring to -55 value corresponds to Clark's "treated wood" in Table 1, not shingles.	Corrections made.
143	76	total metals compared to other studies	Tobiason	Windward Environmental	7th bullet needs citations of other studies being referred to	References now in table.
144	76	total metals compared to other studies	Tobiason	Windward Environmental	last bullet: you are inferring rubber, ondura and EPDM are comparable materials, is that so?	To the best of my understanding of Clark's study, their materials appear to be comparable.
145	77	total metals compared to other studies	Tobiason	Windward Environmental	the ZIN comparisons need discssion as to comparability between the ECY study and literature. Scale is probably the most important variable as noted earlier (panel vs whole roof) and additional sources integrated in whole roof studies often remains as a question.	The issue of scale has been added to much of the discussion comparing our results with literature values.

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146	77	total metals compared to other studies	Tobiason	Windward Environmental	in comparing to Mendez 2010, the Table 1 values appear to be only from their "tank 2" samples, while "tank 1" and "first flush" results are available and worthy of comparisons (Zn was higher than ZIN in these).	This goes back to the intent of Table 1 and the comparisons being made in the Discussion. We are trying to compare concentrations that were post-first flush, rather than first-flush concentrations, which are so much higher. Our sampling technique was designed to sample the whole rain event (within our criteria for an event) for an integrated result that did not skew results to the higher concentrations.
147	77	Table 26	Tobiason	Windward Environmental	thanks for including PSTLA comparison in Table 26. Please add a footnote that the 355 µg/L copper value used in PSTLA for "metal" roof was an error as we discussed 12/18 and as noted in several earlier emails. The correct pooled mean of Good (1993) and Tobiason (2004) copper from "metal" roofing is 22µg/L. Using this value in the PSTLA load estimates cuts the total release in half (27 to 14 tons/yr) and drops metal roofing from 56% to 7% of the total release estimate as noted in my email of 1/11/13.	Foot note has been added to Table 26.
148	77, 90	total metals compared to other studies and Conclusions	Tobiason	Windward Environmental	first sentences in paragraph above T26 need edits to make it clear that you are comparing this study to the PSTLA. Also in last sentence, more appropriate is that PSTLA based estimates on values from "whole roof studies", not a deliberate evaluation of "roofing systems", which would inherently include the scale factors not addressed by this panel study, as well as potential other sources present on whole roofs (components and confounding sources like HVAC, etc). Same comment for page 90 usage.	This portion of the discussion has been changed to address the potential impacts of scale as well as whole roofing systems.

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149	77	table 26	Tobiason	Windward Environmental	separate PAZ from ZIN, two different products should not be lumped here. Same thing for single ply where certain materials were different for As, Zn.	We concur that these are two different products. However, the PSTA study also lumped these products under the heading of metal roofs. The ranges are given for the two. This is likewise true for the single-ply panels, which were all considered BUR in the PSTA study.
150	77	Table 26	Tobiason	Windward Environmental	given the differences between PSTLA and this study, it suggests Ecology should provide updated release estimates and re-ranking of roofing materials in the PSTLA tables so that pollution control priorities can be re-assessed. Ecology should carefully compare their roof study results with each literature value used in PSTLA now that they know more about thinking for roof runoff at least from a raw source perspective.	As indicated in the first RTF meeting, a reevaluation of the release estimates is not part of the scope of this study.
151	78	dissolved metals	Tobiason	Windward Environmental	consider using "dissolved fraction" a more conventional term than "percentage", also check usage of "fraction" in some cases "concentration" is better.	Edits made.
152	78	dissolved metals	Tobiason	Windward Environmental	a lot of the copper data were also J flagged low values so calculated fractions may be meaningless at such low levels.	The table has been revised to indicate highlight data considered reliable.
153	78	Table 27	Tobiason	Windward Environmental	check values, some of the copper dissolved fractions don't agree with calculated values from raw data	Values checked. Minor errors corrected for two panels.

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154	78	dissolved metals	Tobiason	Windward Environmental	are such high dissolved metal fractions worth calculating and reporting? Such high average fractions >>1 suggest potentially serious problems such as data input errors, contaminated filters, analytical problems, etc. Consider providing a better table showing dissolved and total concentrations side by side and dissolved fractions in another column, or possibly a plot of total and dissolved with 1:1 line to show where things were off.	The table has been changed, eliminating some values and highlighting others.
155	79	dissolved metals	Tobiason	Windward Environmental	dissolved metals has certain utility in future studies for certain materials and considerations so probably don't want to dismiss it so quickly.	There appears to be sufficient evidence for the high proportion of dissolved metals both from this study and from the literature. Additional sampling for dissolved metals may not be cost-effective. No change was made.
156	83	SPLP	Tobiason	Windward Environmental	global this section: "leachant" is the term for the SPLP reagent prior to exposing coupons, "leachate" is after the exposure	While your differentiation between leachate and leachate is correct, we felt that our audience may not make this differentiation and could become confused.
157	83	SPLP	Tobiason	Windward Environmental	in last sentence of first paragraph, make a more direct comparison of the SPLP leachant pH with the measured rainfall pH from the glass controls. Also, avoid 3rd party ref to Taylor Assoc (2004) since you have the pH data to compare.	Reference to the measured rain and leachant pHs has been added.
158	83	SPLP	Tobiason	Windward Environmental	note that while after market coatings can be applied per their mfgs recommendations, the coatings may void the warranty of the original roofing material	Comment noted.

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159	84	SPLP	Tobiason	Windward Environmental	in the discussion of shortcomings of SPLP method, you should indicate Taylor 2004 applied SPLP leachant by spray bottle then collected runoff, not in immersion and tumbling approach like this study took. This spray method is one to consider for future.	Addition made.
160	85	SPLP	Tobiason	Windward Environmental	Heinje pers comm 2013 needs listing in refs	Added.
161	90	conclusions	Tobiason	Windward Environmental	second sentence, need to include basis of use statement (i.e. PSTLA Appendix B).	Added.
162	90	conclusions	Tobiason	Windward Environmental	after the second sentence, please add PSTLA Appx B info about the relative usage of the materials in the region, i.e. 70% asphalt shingles, 13% built up, 7% wood shingles and all the rest make up remaining 10%	The selection of roofing materials was based on a number of factors including RTF desires, prevalence of use, and emerging technologies. All of these are mentioned in the Conclusions and discussed more thoroughly in the QA Project Plan; Appendix B of Ecology, 2011a is cited.
163	90	conclusions	Tobiason	Windward Environmental	in first paragraph, mention the Phase 2 work is ongoing and supplemental report will look at these "preliminary" results in context of additional dataset.	Ecology has restructured this section and separated conclusions from recommendations. In the Recommendations subsection, the second round of sampling is discussed.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
164	90	conclusions	Tobiason	Windward Environmental	consider pointing out that findings were generally as expected based on literature and/or known presence of the chemical in the base material (Cu in CPR), a coating (Zn in ZIN), or preservative (Cu and As from CCA in TWO, Cu in AAR). Add note that RTF members explained reasons for finding As in PVC (pesticide) and Zn in EPDM (catalyst). PBDE findings seem inconclusive. Some limited surprises: Cu from AS, Zn from PAZ, TWO and AAR	Some wording modifications have been made to include these points.
165	90	conclusions	Tobiason	Windward Environmental	point out dissolved fractions where you identify elevated metals, i.e. first sub bullet for Cu from TWO was 96% dissolved. Second main bullet seems to overgeneralize diss fractions: copper from AAR and AS averaged around 75% dissolved suggesting some particulate copper was exported.	Wording has been modified to more nearly parallel the text in the Discussion section.
166	90	conclusions	Tobiason	Windward Environmental	for the TWO As and Cu, we heard in 11/13 meeting that supplier thought the results were unexpectedly high compared to their experience with CCA leaching. The text only infers the connection too so you may want to be more clear.	We are reporting what we found. The other literature they provided was conducted on pilings that were continuously submerged, and not directly applicable here.
167	90	conclusions	Tobiason	Windward Environmental	Might add that PAHs were "low" even in runoff from the products most expected to leach them due to petroleum product content: the asphalt shingles and built up roof panels	Modification added
168	90	conclusions	Tobiason	Windward Environmental	second to last bullet, consider adding that study results also suggest PSTLA rankings of roofing materials as sources of metals would change.	Comment noted

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
169	90	conclusions	Tobiason	Windward Environmental	XRF method and results not mentioned in conclusions, was it usefue screening tool? What limitations? Should it be used in future? Should mention the chromium findings from XRF, which back up your recommendation to analyze chromium in future studies on CCA treated products. Also should point out chrome in XRF results for PAZ (panel and coupon), and polyester painted galv coupon were unexpected and apparently relate to chromate primer detecatble by XRF below the exposed surface.	Added future sampling for chromium to the recommendations.
170	91	conclusions	Tobiason	Windward Environmental	for PBDEs, leaching was minimal apparently because no panel/product contained flame retardants. Yet one coupon tested positive for bromine with XRF indicating it had them, and the PAZ panel also had a bromine hit. So probably want to add something to the effect that PBDE results have limited utility.	Comment noted. However, the recommendations indicate a much reduced monitoring scheme for PBDEs, inferring their limited value at this age of the panels.
171	91	conclusions	Tobiason	Windward Environmental	You might add that SPLP tests were intended to reflect on source control options as recommended by Ecology and certain after market coatings vendors. But please add that the SPLP tumbling and submersion approach was highly unrealistic to simulate roofing material leaching and because of this the results would be expected to be low biased. Also might want to note that after market coatings can void the original roofing warranty.	Some language added.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
172	92	recommendations	Tobiason	Windward Environmental	in first paragraph after bullets, instead of pointing to PSTLA, you should be pointing out the ZIN results were comparable to other panel studies of Galvalume in Table 1, which is more comprehensive basis for comparison (after some fixes indicated in earlier comments). Add that the study results and lit indicate key differences between panel and whole roof studies is scale and contact time. Thus, to more accurately assess Zincalume and/or Galvalume, full scale studies are needed such as SeaTac. You are right in pointing out the other potential Zn sources that need to be assessed in whole roof studies.	Comment noted.
173	92	recommendations	Tobiason	Windward Environmental	typo "EPCM"	Corrected.
174	92	recommendations	Tobiason	Windward Environmental	a one year study of new roofing materials with design lives of 20, 30 or more years could be insufficient; certain effects could occur as materials degrade near the end of their design lives	We concur.
175	92	recommendations	Tobiason	Windward Environmental	glad to see the recommendation to not use the same SPLP procedure from this study again, it was highly unrealistic. Consider recommending the spray bottle method we used at SeaTac (Taylor Assoc 2004).	The spray bottle technique was mentioned in the Discussion section.
176	92	recommendations	Tobiason	Windward Environmental	in general, consider suggesting whether certain panel scale results from this study should eventually be validated in full scale roof data	A subsection has been added to the Recommendations to address this (Longer Term Recommendations).

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
177	92	recommendations	Tobiason	Windward Environmental	This study and report lack important context of environmental transport, fate and roof runoff treatment options. Findings of "high" or "elevated" concentrations should not be interpreted at face value. Report should caution readers that transport, fate and treatment assessments are needed to put results from this study (and roofing runoff in general) into a better context to guide decision making. At least one good place to mention these points is fourth paragraph after bullets.	The scope of this study clearly was not intended to assess fate and transport issues. This will be best addressed in the "white paper." The issue has been added to the Longer Term Recommendations section.
178	92	recommendations	Tobiason	Windward Environmental	Report should also indicate findings may be helpful in certain NPDES stormwater permit settings, e.g., as related to source tracking investigations to isolate industrial activity from roofing sources but should not be used for compliance decisions without appropriate consideration of various site specific factors. Many ISGP permittees are having to treat zinc in metal roofing runoff to meet the static benchmark which may be over or under protective depending on site specific bioavailability.	At the beginning of this study, we were cautioned not to make comparisons with water quality criteria or other NPDES-related concentrations. While we have talked about these concentrations in meetings, this report will not address the NPDES issue. We have briefed the Water Quality Program on the findings.
179	92	recommendations	Tobiason	Windward Environmental	a risk assessment should be considered along with the hazard assessment	The need for a risk assessment is implied in the Longer Term Recommendations.
180	92	recommendations	Tobiason	Windward Environmental	add recommendation that Ecology should re-evaluate roof rankings as sources in PSTLA report given the differences found in this study. A re-ranking could be important if and when general roofing assessments in the region arise again.	A reevaluation of the sources has not been within the scope of this project since its inception. With resources available to it, Ecology is using the PSTA study as a springboard to conduct studies of sources identified in the study as major contributors of specific toxics. Ecology is more likely to spend limited resources on controlling major sources of toxics

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						than redoing an estimate.
181	Appx A	Appx A	Tobiason	Windward Environmental	nice photos and descriptions; adding the material code abbreviation to each panel description will aid readers.	Panel abbreviations added.
182	Appx A	Appx A	Tobiason	Windward Environmental	for the AS and AAR replicate panels, apparently 1 of the 6 suppliers was included only twice, not 3 times like the other 5 on each panel (6x3=18 courses, text says 17 courses installed), so state which supplier and if rotated or not for each panel.	The specific suppliers' names were not provided in association with specific shingle types (courses). This was an attempt to provide anonymity for the suppliers.
183	Appx A	Appx A	Tobiason	Windward Environmental	for the PAZ panel, where were the hot dip galv fasteners used and how well were they covered or exposed? Could they have explained the higher than expected Zn for PAZ?	Five fasteners (which were exposed to collected precipitation) were used at the top end of the panel. These fasteners were coated with paint that prevented contact directly with the galvanized surfaces of the fasteners. Appendix A has been edited to make this clear.
184	Appx A	Appx A	Tobiason	Windward Environmental	CPR panel, specify units after "4 pounds per square"	Change has been made.
185	Appx A	Appx A	Tobiason	Windward Environmental	CTI panel needs information	Information has been provided by the concrete tile panel installer.

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186	Appx A	Appx A	Tobiason	Windward Environmental	for the ZIN panel, panel, where were the hot dip galv fasteners used and how well were they covered?	The 30 unfinished screw fasteners are exposed to collected precipitation. These are not described as "hot dip galvanized fasteners" in Appendix A but rather as "unfinished screw fasteners." These were installed per standard installation.
187	Appx D	Appx D	Tobiason	Windward Environmental	each of the 3 replicate results for the 3 AS panels should be reported in addition to the average listed in the tables.	These data are available from Appendix F and are not included in Appendix D.
188	Appx D	Appx D	Tobiason	Windward Environmental	Table 9, storm #1 Cu result for CPR should have an "a" qualifier since was average of two splits.	Qualifier added here and where other qualifiers were missing.
1	12		Trim	Futurewise	Suggested edit: The study found that approximately 80% of the zinc, 60% of the cadmium, 20% of the arsenic, and 10% of the copper released in the Puget Sound basin COULD BE associated with roof runoff	Wording changes made to indicate that the estimated percentages were thought to be released in runoff from roofing systems.
2	19		Trim	Futurewise	Suggested edit: Age of Roofing Materials SPARSE literature THAT IS AVAILABLE contains conflicting reports about the relationship between the age of the roofing material and the amount of metal leached from it during precipitation events.	Wording modified for clarity.
3	22		Trim	Futurewise	Suggested edit: Vegetated roofs OR THE MATERIALS USED TO CONSTRUCT VEGETATED ROOFS can also contribute heavy metals and other pollutants to runoff	Change made.
4	22		Trim	Futurewise	Suggested edit for clarity: Repairs often occur during the wet season AS IT IS often during storms when the leaks become apparent.	Change made.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
5	26		Trim	Futurewise	As this page includes a number of caveats, I think it should also include the statement that most of the materials were donated by roofing companies and although they endeavored to provide typical materials, it was not a blind study.	Sentences have been added to the Purpose of the Study section indicating that the roofing materials were donated by manufacturers and thus did not represent a random selection of materials available in the Puget Sound region.
6	58		Trim	Futurewise	When making statements about results (first sentence), I suggest adding a clause about the glass panel results in the same sentences (here and elsewhere in the report).	We have done this where feasible, but still need to keep sentences from excessive length.
7	63		Trim	Futurewise	should the title of this section be "results"? And then have "discussion" start later?	The analysis of leaching of HDPE was not in the QA Project Plan. I conducted this analysis because 1) I could not find any literature that looked at phthalate release from HDPE; and 2) was concerned about future scratches in the Teflon®-lined HDPE gutters. This was such a small part of the report that I did not feel that it warranted a special subsection in the Discussion, so I included a few sentences in the Results only.
8	64		Trim	Futurewise	this is kind of a confusing sentence. If this means in the Lacey area, then it might be clearer to say that: The sampled storms represented between the 52nd percentile to the 91st percentile of the rainfall in a 24-hour period for this location; and average intensities ranged between the 40th and the 96th percentile	Change made.
9	77		Trim	Futurewise	Suggested edit: Table 26 (and elsewhere): I would talk about the Ecology report as being "estimates" or "modeled results" rather than "study results."	Changes have been made to indicate the Puget Sound Toxics Assessment report estimated potential releases of contaminants.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
10	80		Trim	Futurewise	Does Lacey have a lot of wood burning stoves? Seems like it would be good at least discuss what could be possible reasons for higher PAHs on the glass	Lacey probably does not have higher wood-stove usage than other communities in the Puget Sound regions. I think it is more likely that the higher fluxes came from the fact that our study was a) not designed to look at atmospheric deposition and b) dry periods were not sufficiently long to be truly representative. Also we are adjacent to the Ecology parking area, and smokers walk by the site. We added a sentence about the adjacent parking area to the description.
11	83		Trim	Futurewise	here and elsewhere, it would be easier for the reader if some simple statements could be made about data results (in addition to referring to tables). In this example (However, by comparing the PBDE concentrations in the runoff from the glass control panels to those from the roofs, one can conclude that the new roofing materials in this study do not appear to be leaching PBDEs to the runoff.) it would be great to say if the levels were indeed the same in the glass panels compared to the other samples. Now a days, when people read these reports, we are often doing it on the computer and so it is difficult to flip quickly to the tables as we are in the midst of a text section.	Where figures or tables from the Results are mentioned, their page numbers will be provided to make maneuvering through the document easier. We considered hyperlinking the tables and figures to the narrative, but we were concerned that the entire document could become corrupted.
12	90-91		Trim	Futurewise	Suggested edit for ease of reading: I would make the results a bit more parallel. For example: "PAHs in runoff from the roofing materials were low and not substantially different than the glass controls." and "For both the steep and low-slope roof, the new roofing materials in this study did not appear to be leaching PBDEs to the runoff."	Changes have been made to the Conclusions to create more parallel construction.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
13	92		Trim	Futurewise	For future testing, I would suggest doing at least one round of all metals. Aging may cause deeper leaching, loss of coatings, etc.	A recommendation has been added.
14	92		Trim	Futurewise	A significant need is to test the roofing components. I would really like to see that as part of Phase II.	The Recommendations section has been restructured and the first recommendation under Long-Term Recommendations is to assess other roofing components.
1	8	Abstract	Batts	King County Natural Resources	It is worth noting that As-total from PVC, while the median is only 2.4% of TWO median value, at 38.3 ug/L it is 766 x the groundwater quality standard (0.05 ug/L). The maximum PVC As value of 117 is 2340 x the groundwater quality standard. By comparison to mention of 'moderately' elevated Zn from Zinalume and EDPM, it seems reasonable to at least assert the same (moderately elevated) for As from PVC.	The abstract is limited to 300 words. With addition of comparison to the original Toxics Loading study, we have had to reduce the detail in the abstract.
2	8	Abstract	Batts	King County Natural Resources	Minor point - the sentence "The phthalates may have been a constituent of the vacuum pump oil used in pressure treating." is a Discussion detail that seems unnecessary and consequently a bit distracting in an Abstract.	This statement has been removed from the abstract for brevity.
3	12-13	Overview	Batts	King County Natural Resources	Lest there be any confusion, please expand on "releases of toxic chemicals to the Puget Sound Basin" to make it clear that concern is for concentration effects on all receiving waters: streams, lakes, and groundwater, in addition to concern regarding loading to Puget Sound itself.	A note has been added to this section.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
4	13-14	Metal Roofs	Batts	King County Natural Resources	Why are some cited studies in the narrative not included in Table 1? e.g. Barron (2000) and Karlén et al. (2002)? There may be others. If first-flush and/or single grabs are not included in the tab	For more relevance, Table 1 has been limited to those studies in which 1) total metals were measured, 2) steady-state flow (i.e., post-first flush flow) was monitored, or 3) event mean concentrations were calculated by the authors.
5	14	Metal Roofs Paragraph 3	Batts	King County Natural Resources	Please clarify re: "steady-state runoff or event mean or median concentrations". Does this mean one of the three methods, or is intent to imply equivalency between the methods? The given definition of 'steady state' is not equivalent to other methods which do capture the first flush, e.g. flow-weighted event mean concentration and whole storm volume sampling. Are reported means and medians from flow-weighted samplers? grabs? entire storm runoff (as in this study)? It would be helpful to add a column to the table for sampling method, and ideally another for number of aliquots per (or target # or mean # of aliquots where the reported value is from multiple events).	The literature reports runoff from roofs as first- flush or steady state, or, in some cases, as event mean concentration. In an attempt to compare apples to apples, Table 1 reports those values from post-first-flush literature or event mean concentrations only. Additional clarification has been added to the text.
6	14	Metal Roofs	Batts	King County Natural Resources	Negative values resulting from subtraction of deposition from runoff might imply adsorption by the roofing. Very small negative values could in some cases result from sampling variability and/or measurement error. Please consider a bit of expansion on the subject.	The author (Clark) represented her data in this fashion. Since her results are a compilation of two years' worth of rain event data, the explanation of aerial deposition seems to be the best explanation.
7	15	Table 1 Heading, second line	Batts	King County Natural Resources	The sampling method language differs from that in the narrative. Please see prior comment regarding the narrative.	Table 1 subtitle corrected.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
8	15	Table 1	Batts	King County Natural Resources	Zinc concentrations are shown from two studies from France. Golding (2006) cited elsewhere in the report cites two other studies: "Concentrations of total zinc in galvanized roof runoff have been reported in a range of 1,100–12,200 µg/L (Good, 1993; Quek and Förster (1993); Thomas and Greene, 1993). Quek and Förster are cited on pg 12 of this report. Why were these values left out of Table 1?	See response to Batts' comment 4.
9	15	Table 1	Batts	King County Natural Resources	Golding (2006) cited elsewhere in the report cites additional information regarding Galvalume; i.e. "The Port of Seattle monitored stormwater runoff from galvanized (Galvalume ®) roofs at Sea-Tac International Airport and found similar concentrations: 400–15,000 µg/L total zinc (12,000 dissolved, maximum; Indumark, 2004)". Why is this not included in Table 1?	This Tobiason study has been added to Table 1. The Golding study did not meet the criteria for Table 1 as described in the response to Batts' comment 4.
10	17	Table 1	Batts	King County Natural Resources	Table 1 indicates 217 ug/L for Cu. Zobrist et al. (2000) list three runoff concentrations: Leveling Co = 217 ug/L; Mean 0-2 mm runoff depth = 304 ug/L; and Mean = 842 ug/L. Please explain the distinction between these values and why the lower value was chosen for Table 1.	The Zobrist et al. (2000) leveling off concentration (Co) appears to be the concentration that most nearly approaches steady state flow (although it is slightly higher than his graphs of steady state flow). Thus, these concentrations were used for both the clay tile and the polyester roofs represented in Table 1. I did note that the samples were obtained after flow through a copper gutter. This was added to the table.
11	20	Preservatives in Roofing Materials	Batts	King County Natural Resources	Suggest changing the second sentence to "Treated wood shingles also leach these <u>same</u> compounds <u>at higher concentrations</u> , as well as other compounds (Table1).	Change made.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
12	20	Preservatives in Roofing Materials	Batts	King County Natural Resources	Differences between Clark (2010) and Persson and Kucera (2001) results could also result from differences in wood species and/or quality, e.g. even if same species, density differences depending on tree ring density; and if these were outdoor studies, climatic/weather differences could also factor.	No one in the literature has mentioned species difference as a reason for greater release of copper concentrations.
13	20	Following Preservatives in Roofing Materials	Batts	King County Natural Resources	Need to add a brief section discussion after-market treatments for moss control and roof cleaning.	We have not researched the topic, which is beyond the scope of this study. This topic should be the focus of a separate study.
14	24	Residence Time	Batts	King County Natural Resources	Suspect a typo: Sentence 2/3 down in paragraph says "Thus that shallower sloped roofs would allow longer contact time" Suspect 'that' should be replaced with 'the'.	Correction made.
15	24	Residence Time	Batts	King County Natural Resources	Same paragraph as noted above. A bit confusing. The 'thus' statement regarding residence time doesn't follow cleanly from the prior sentence discussing slope and area exposed to precipitation, but not discussion residence time. I think the point is that steeper slope = lower precip volume in relation to a given area, but the contact time is decreased because of the steepness; and a shallower slope = higher precip volume but longer residence time for a given area. The question then becomes how to model this.	Sentence revised to indicate that steeper roofs reduce contact time.

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16	26	Purpose of the Study 1st bullet under "The primary objectives of this study were to:	Batts	King County Natural Resources	"Determine the range of concentrations of specific chemicals leached from various <u>new</u> roofing materials" (recommend adding the word 'new')	Changes made.
17	26	Purpose of this Study	Batts	King County Natural Resources	Need to add to the list of things not studied (e.g. effects of HVAC, gutters, downspouts), after-market moss control and roof cleaning compounds.	Change made.
18	26	Purpose of the Study	Batts	King County Natural Resources	Please note why vegetated roofing was not included. I assume this was because it's not commonly used (there is a note to that effect, i.e. commonly used roofing was tested); however, there is a huge push to maximize LID, so it is important to evaluate the potential for unintended consequences with green roofing.	The change is not needed because of the caveat that we are looking at commonly used roofing materials. We did try to solicit involvement by a vegetated roof installer for Round 2, but were not successful, because of the cost of the study to them.
19	26	Purpose of the Study	Batts	King County Natural Resources	Please include a section on analyte selection. Some of this is pretty self evident from prior citations of the most commonly studied and found analytes (e.g. Cu and Zn). What's not obvious is why e.g. chromium and organic biocides were left out. There is also a large list of fire retardants besides PBDE, including but not limited to boron compounds, antimony compounds, a number of organohalogens besides PDBE (e.g. tetrabromobisphenol A), organophosphorus compounds, and halogenated organophosphorus compounds. A section summarizing the thought process is warranted.	The results of the PSTA study identifying copper, arsenic, zinc, and cadmium are discussed in the Overview. Selection of the parameters is discussed in the QA Project Plan which is referenced in the Methods. We did not feel it was necessary to repeat, especially because much of this was discussed with the RTF.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
20	26	Purpose of the Study Last paragraph on page	Batts	King County Natural Resources	" ... and as such serves as a pilot study." <i>Important to retain this.</i>	This was retained.
21	36	Laboratory Contaminants	Batts	King County Natural Resources	The suggestion is made to use a less sensitive method. This does not solve the noise problem, it simply masks it at the expense of loss of information. The solution is to ferret out and eliminate the contamination to the greatest extent feasible.	We agree that a higher MDL masks the issue. However, for the purposes of assessing these organics from roofing materials, it would be more cost effective to use 8270D. "Less costly as a screening tool" was added to the last sentence of that section.
22	36	Variability	Batts	King County Natural Resources	The only true replicates are the three asphalt shingle panels using the same materials. Should be made clear that this only represents variability for that material and slope, and does not reveal anything about variability for the other roofing materials.	This section has been changed to differentiate between the split and replicate RSDs.
23	36	Variability	Batts	King County Natural Resources	MEL used to state in its reports that RSD values exceeding the QA/QC goals were non-indicators when the measurements were close to the reporting limit. There should be no call for a less sensitive method to mask these high RSD values., not should they be cause for rejecting the data. Again, use of a less sensitive method will result in loss of information.	This is essentially what the Mathieu paper states. Data were not censored on this basis when concentrations were low.

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24	37	Summing Organic Constituents	Batts	King County Natural Resources	Use of 1/2 the RL can lead to analysis error. Please see Helsel: Helsel, D. (2005). Insider Censoring: Distortion of Data with Nondetects. Human and Ecological Risk Assessment, 11(6), 1127-1137. Helsel, D. R. (2005). Nondetects And Data Analysis: Statistics for Censored Environmental Data: Wiley Interscience. Helsel, D. R. (2006). Fabricating data: How substituting values for nondetects can ruin results, and what can be done about it. Chemosphere, 65(11), 2434-2439. Helsel, D. (2009). Much Ado About Next to Nothing: Incorporating Nondetects in Science. Ann Occup Hyg. and http://practicalstats.com/	After researching the options in managing non-detect values that need to averaged with detect values, we realized that any assumption, (the RL, MDL, or half of either of these values) would lead to a skewing of the data. We elected to err on the side of lower concentrations and use 1/2 the MDL. This is explained in the narrative. For values not detected in either the sample or its split (or replicate) no value (i.e.. zero) was added to the sum of the organics.
25	66	Analysis of Total Metals in Runoff	Batts	King County Natural Resources	The statistical test significance level is shown as $\alpha = 0.005$. Just checking to see if that was the value.	That is correct.
26	66	Arsenic	Batts	King County Natural Resources	"The treated wood shake roof (TWO) was treated with chromated copper arsenate (CCA), but did not meet the Western Wood Preservers Institute (WWPI) best management practices (BMPs) to minimize leaching" This suggests need to get for testing some shingles that do meet the industry's BMPs. This should be added to the existing panel array; i.e. Ecology should continue to test the substandard shingles because there's no way of knowing which shingles in use meet the standards and which don't.	Based on subsequent input from RTF members who investigated this issue, the TWO shakes used did, in fact, meet the BMPs, but not the paper certification of such. The text has been revised to reflect that.
27	67-70	Discussion Analysis of Total Metals in Runoff	Batts	King County Natural Resources	The horizontal cutoff at the maximum ND level is a good feature. Recommend using notched box plots to indicate estimated 95% confidence limits (Systat and R can do this).	We did not feel 95% confidence intervals were warranted when using asterisks to depict statistically significant differences in the figures.

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28	74	Impacts of Precipitation Amount	Batts	King County Natural Resources	Between Figure 13 and Figure 14 there are some orange brown cots that are indicated in Figure 13 as representing TWO As concentration over time. Needs to be fixed.	These will be remedied by our technical editor for the final report.
29	89	Table 33. List of potentially hazardous compounds found in coating products	Batts	King County Natural Resources	Pg 62, Organics, says, "To determine whether coatings could leach of organic contaminants, the laboratory analyzed PAHs, phthalates, and PBDEs in the leachate". Table 33 lists other potentially hazardous compounds, which need to be tested for leachability as well.	This is correct. Some of the compounds on the MSDS would have volatilized long before they reached the lab. Others are not testable by standard methods. This was the initial screen.
30	91	Recommendations	Batts	King County Natural Resources	<i>"For the treated wood roof, future studies should consider measuring chromium"</i> . Agree, and additionally recommend changing to "should measure chromium: total and dissolved Cr(III) and Cr(VI); especially CR(VI). Should also be measured for any roofing with a chrome/chromate coating. Cr(VI) is of particular concern.	Future researchers will need to make these decisions.
31	91	Recommendations	Batts	King County Natural Resources	2nd bullet: suggests decreasing frequency of Cd analysis. Generally agree except for TWO, which had runoff concentrations in the range of both acute and chronic freshwater criteria albeit at fairly low hardness levels. Recommend continuing to monitor TWO runoff for Cd on a regular basis.	Comment noted.
32	92	Recommendations	Batts	King County Natural Resources	First bullet suggests decreasing frequency of analysis for Pb. Recommend continuing regular Pb analysis at least for the eight roof types that had Pb-diss at levels within range of the FW WQS for lead, and especially for copper roof which had the highest hit (may have been an anomaly - all the more reason for more testing.)	Comment noted.

Item number	Page Number	Section or Subsection Heading	Commentor's Name	Commentor's Organization	Comment and Suggested Change	Response
33	92	Recommendations	Batts	King County Natural Resources	Errata: third paragraph, first line, last word: EPCM should be EPDM.	Corrected.
34	92	Recommendations	Batts	King County Natural Resources	<p><i>"The results collected in this initial investigation do not provide Ecology with a long enough period of record to have confidence in making decisions regarding future actions related to assessing roofing system or whether source control actions are needed for the materials tested"</i></p> <p>Perhaps in a vacuum, but this is in addition to a body of existing information. While this is a pilot study - sample size is limited, concentrations may change over time, and some QC issues need to be resolved; at least for metals in runoff the results are quite consistent with existing literature, adding to a hard to ignore body of evidence. According to Ecology's current stormwater manual, only bare metal roofing and any roofing "subject to venting significant amounts of dusts, mists, or fumes from manufacturing, commercial, or other indoor activities"* (Ecology does not define significant here) is considered pollution-generating. The study should continue and expand in scope - there are still unanswered questions; but given the values measured during the study's time period, even if concentrations decrease later, from both environmental protection and regulatory points of view, there is no such thing as an acceptable 'aging' period during which knowingly discharging pollutants is OK. It is difficult to see how Ecology can avoid the evidence pointing to expanding the list of roofing materials that should be considered pollution generating. One of the limitations of the study is that it is not intended to include HVAC, flashing, or gutter/downspout drainage systems,</p>	Comment noted.

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					nor does it look at after-market roof treatments (moss control and cleaning agents); these will to one degree or another add pollutant loading to roof runoff. There are also limitations on the measured parameters (as mentioned before, at least but not limited to chromium and organic biocides). That said, a designation as 'pollution generating' isn't necessarily pollutant-specific, although knowledge of elevated heavy metals dictates use of enhanced treatment over basic.	
35		Recommendation Addenda	Batts	King County Natural Resources	Recommend that other composition shingle panels be tested, each representing a single (not mixed) batch from independent lines and/or manufacturers.	The point of using "mixed" asphalt shingle panels from the six manufacturers who sell in the PNW was to get an average of the concentrations of metals, etc. in the runoff that are released in this most prevalent roofing type.
36		Addenda	Batts	King County Natural Resources	Green roof runoff: Suggest checking for potentially relevant material: Nicholson, N., Clark, S., Long, B., Spicher, J., & Steele, K. (2009, May 17-21, 2009). Rainwater Harvesting for Non-Potable Use in Gardens: A Comparison of Runoff Water Quality from Green vs. Traditional Roofs. Paper presented at the World Environmental and Water Resources Congress 2009: Great Rivers, Kansas City, Missouri.	We reviewed the paper by Nicholson et al. (2009) but did not include it in literature review.
37		Addenda	Batts	King County Natural Resources	Please bear in mind that if the panels are moved, some site-to-site variability could be introduced into the results.	We agree.

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1	8	Abstract	ARMA	ARMA	Though the report has an abstract and an introduction, neither of these communicate the message that the key finding of this study is that the roofing materials studied leached two to three orders of magnitude less than what was estimated in the 2011 report. ARMA recommends that this message be clearly communicated in the report.	The abstract has been changed to include a comparison between this study and the previous Ecology study.
2	12	Introduction	ARMA	ARMA	The introduction largely summarizes the premise that roofing is a significant contributor of metals to the Puget Sound based on the 2011 report. While it is acceptable to reference this as the justification for conducting the study, it would be helpful to highlight at that point that the results obtained by the study were found to be significantly different from the 2011 predictions and that more work is needed to understand the reasons for this difference and the impact of these roofing materials on the Puget Sound. ARMA recommends that this be clearly communicated in the report.	We have added this to the Abstract, but in Ecology's scientific papers, results and recommendations for future investigations are not included in the Introduction. Ecology has added an Executive Summary and will be developing a Focus Sheet that will provide information that is easily digestible for the public.
3	12	Introduction	ARMA	ARMA	ARMA believes that an executive summary page may be more suitable to the nontechnical readers and various nonscientific based government decision makers. In that summary, the gap from the original estimate could be noted along with the need for follow-up investigations of other roofing components as well as fate and transport studies of roof run-off to assess the actual amount reaching the Puget Sound. ARMA recommends that an executive summary page be added to the report.	An Executive Summary has been added.
4	13	Introduction Overview	ARMA	ARMA	Modified BURs is poorly described "...asphalt layered with a substrate such as APP or SBS..."	Description provided by John Ferraro, Thank you!

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5	20	Introduction Overview	ARMA	ARMA	Refers to CCA-treated shingles -- assume this is wood. When using the word shingles should indicate what kind -- asphalt shingles or wood or ??	Change made.
6	38	Results	ARMA	ARMA	The question about one of the non-AR shingle coupons having a very high copper content XRF result versus the rest of the non-AR coupons should be addressed. From the report it is not clear to ARMA what was done, therefore ARMA recommends some more description of how each sample, coupon, and panel were obtained, qualified as representative, labeled, used, and measured.	Language has been added to describe how the coupons were obtained, labeled, and measured. Ecology worked with PABCO (panel installers) to identify the source of the copper in the one XRF's sample. We were not able to determine whether this was a labeling error or just manufacturing variability. As a result, this coupon was not represented in Table 7, but it was discussed in the narrative as an outlier.

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7	38	Results	ARMA	ARMA	<p>It is ARMA's understanding that Ecology received samples from a variety of manufacturers of both AR and non-AR shingles from which panels were built. Table 8 reports the averaged XRF results at time equals 0 of the various shingles in the AR and non-AR groups. Table 8 does not seem to indicate that any high copper outlier was present. Table 7 on the other hand does show the high copper non AR outlier was present in the supposedly representative set of coupons. That Table 8 and Table 7 differ in XRF results raises questions: is there a test method issue, a sample selection issue, sample labeling issue, etc. Clearly one of the coupons doesn't represent the areas measured on the panels. ARMA recommends that this discrepancy be resolved prior to publishing this report or at least prior to starting the second part of the study.</p>	<p>See response to previous comment about how we managed the non-AR coupon XRF results.</p> <p>Following the suggestion of the RTF, Ecology did a more in-depth XRF analysis of the installed panels and found that one of the types of shingles had higher copper than the others. Further, the type of shingle on the AS-3 panel had slightly higher copper levels than the AS-1 and AS-2. Since all the shingles applied to these three replicates came from the same lot, we have attributed the elevated copper concentrations in the one strip of AS-3 shingle and in the AS-3 runoff to manufacturing variability (with concurrence of the manufacturer).</p> <p>More detail about the installation of the asphalt shingle panels and products from six manufacturers was added to the Methods section. We have also added a description of the subsequent XRF analysis of the 6 shingle types on AS-1 through 3. The analysis of the subsequent information is presented in the Discussion.</p>

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8	38	Results	ARMA	ARMA	It should be a relatively straightforward task to inspect the granules on the coupon and the granules on the panel that the coupon is supposed to represent and determine if copper granules are present on one and not on the other. ARMA believes that the coupon has copper granules and was somehow mistaken as non-AR but that the shingle installed on the panel is correct and doesn't have copper granules on it. It would be desirable to confirm that.	The manufacturers of the shingles installed have not been identified to Ecology. After the second round of more extensive XRF analysis of the panel shingles (3 XRF analysis for each type of shingle and for each panel), we did have a conversation with one of the manufacturers. One of the 6 single types had more copper than the others. But that shingle type was still within the range copper measured on the non-AR coupons - except for the outlier that has been removed from the table and only remains in the narrative. For that shingle type, panel AS-3 had the highest average copper concentrations - again still within the range of the coupons. The shingle manufacturer indicated that the variation between panels may be manufacturing variation. This information has been added to the text in the Discussion section.
1	8	Abstract	Hubbard		Line 7-8 it states that "concentrations of arsenic, copper and zinc were substantially elevated" and in line 12 it states that the zinc levels were "moderately elevated". Line 8 should say "arsenic and copper were substantially elevated" and then line 12 would remain the same.	We have changed the wording in the abstract to reflect statistically significant differences.
2	12	Overview	Hubbard		Line 5 in the overview the addition of the word may between "materials" and "have". Some roofing materials do not have the potential to release all of the items listed.	Correction made.

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3	37	Variability	Hubbard		Line 14 it say's " sums of the each" it should say "sums of each".	Correction made.
4	38	Results	Hubbard	Single Ply Roofing Institute (SPRI)	bullet number 5 what Hubbard pointed out that there was no Bromine in the TPO sample that was weathered by XRF. How were there any hits in the rain events that looked for specific Brominated FR's.	The language in this section was clarified to distinguish between coupons and installed panels. Also note that in the section on PBDE Results, a change was made to indicate that PBDEs are semi-volatile compounds and can therefore be aerially deposited.
5	65	Discussion	Hubbard	SPRI	Line 1 than instead of that.	Correction made.
6	77	total metals comparisons to other studies	Hubbard	SPRI	Where it says table 26 at the end of that sentence it should be "this study" the s is missing.	Correction made.
7	79	PAH's	Hubbard	SPRI	6th line from the bottom should be than instead of that.	Correction made.
8	90	Conclusion's	Hubbard	SPRI	5th line from the bottom missing or have an extra ().	Correction made.
9	92	Conclusion's	Hubbard	SPRI	Line 6 it should be EPDM.	Correction made.
1		Abstract	Kriner	Metal Construction Alliance (MCA)	3rd paragraph refers to "new" roofing materials. List examples of new roofing materials here. Define "new".	The Abstract is limited to 300 words. Instead of adding a definition here, we have added it to the Purpose of the Study section.
2		Introduction	Kriner	MCA	suggest changing 1st sentence to read "A previous literature review by the Washington ...". The use of word "study" suggests testing rather than a literature review.	The sentence was changed to explain that the study applied literature values to determine estimates of releases of contaminants from various sources in the Puget Sound basin.
3	12	Overview	Kriner	MCA	suggest changing 3rd paragraph to read "...identified roof runoff to be a potentially	Correction made.

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					significant contributor.."	
4	22	Vegetated Roofs	Kriner	MCA	<p>sentence reads "The Herrera study noted that vegetated roofs reduced both the volumes and loadings from the vegetated roof compared with a painted Zinalume® roof. Don't vegetative roofs reduce the volumes and loadings compared to any other type of roof aside from vegetative roofs? Why single out the comparison to Zinalume roof in this section? In fact, why even mention vegetative roofs in this section when they are not part of the test matrix of roofing materials?"</p>	<p>Vegetated roofs do reduce the volume of runoff and can, if contaminants are not introduced from the media, reduce the loads. The comparison of vegetated roofs to a painted Zinalume® roof was made by the authors. We did clarify that the comparison to the Zinalume® roof is one that the authors had made from their evaluation.</p> <p>Because vegetated roofs are being encouraged as one Low Impact Development technique, they deserve at least a short discussion in the literature review.</p>
5	23	pH	Kriner	MCA	This section describes the impact of pH on metal concentration, but it does not identify which roofing materials are the subjects of the studies noted.	Wording has been added to this section to indicate that metal roofs or roofs with metals as part of their matrix would be most affected by pH.
				MCA	Also, a type-o in sentence: They also reported that runoff rates are a function of the corrosion rate ;;, thus they measured significantly higher runoff loads in the highly industrialized areas of Belgium, than in Stockholm.	Correction made.

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6	70	Zinc	Kriner	MCA	this section lists roofs that were 10-100X lower in zinc than Zincolume and EPDM but were statistically significantly higher than their glass controls. Why was this comparison done only with regard to zinc when such a comparison was not done with any of the other metals or chemicals?	Where the metals concentrations in the runoff from panels were significantly different (statistically) than the glass for any of the metals, those differences are called out in the figures and narrative. The discussion of zinc in the runoff from the panels parallels that of copper where the runoff was multiple times higher than the other panels, and yet the AAR and ASA were still statistically higher than the glass control panel.
7	87-89	Review of MSDSs for Coatings	Kriner	MCA	The Ecology report is focused on potential aquatic toxicity in the Puget Sound basin. Why even introduce MSDS and human toxicity into this report? I don't believe it belongs in this kind of report, and only serves to confuse the reader about the scope of this project.	The QA Project Plan identifies review of the MSDS as an initial step to assess whether the coatings are exchanging one contaminant for a potentially equally toxic contaminant.
8	91	Recommendations	Kriner	MCA	Before recommending more testing of roofing system components and more rain events, etc. wouldn't it be prudent to determine what the safe harbor levels of the dissolved metals and chemicals are with regard to aquatic toxicity in the Puget Sound basin?	In the Draft QA Project Plan, we had included a comparison of runoff concentrations with water quality criteria. This raised some objections, because a direct comparison does not account for reductions during fate and transport to a water body, so these comparisons are not included in the report. We did make some comparisons to the Industrial Stormwater General Permit benchmarks at the November 13, 2013 RTF meeting. However, these will not be included in the report. Readers are free to identify potentially relevant regulatory concentrations.

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1	8	Abstract	Gorsuch	Copper Development Association (CDA)	Suggest including range of zinc values in sentence "Zinc levels in the runoff from the Zincalume® and EPDM roofing were moderately elevated compared to the other roofing materials."	Ranges have been added.
2	13	Introduction; Overview; Metal Roofs	Gorsuch	CDA	Suggest noting "first flush" of 30-year old copper roof likely resulted in 5.4 mg/L value in "Karlén et al. (2002) reported runoff from copper roofing materials ranged between 1.8 and 5.4 mg/L for new and 30-year old copper, respectively." Currently the range is skewed, citing extremes released (low value from one copper source and high value from second copper source) from the Karlén et al. (2002) reference. The appropriate way to cite the ranges of these data is 1.8 to 3.9 mg/L and 2.4 to 5.4 mg/L, respectively.	Sentence has been modified as suggested.
3	14	ditto	Gorsuch	CDA	Delete "called" in phrase "...they termed called dezincification."	Correction made.
4	23	Introduction; pH	Gorsuch	CDA	Delete "ant" in phrase "... a pH of 4.3 than ant at a pH of 5.7." Change "rat" to "rate" in "... function of the corrosion rat;,"	Corrections made.
5	23	Introduction; Rainfall Intensity	Gorsuch	CDA	Although the following statement is true, dissolved metals are quickly bound by organic matter making them less mobile. This should be mentioned. "Dissolved metals are more mobile in the environment than particulate metals."	A statement has been added to indicate the reduced mobility of dissolved metals when bound to organic matter.

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6	26	Introduction; Purpose of Study	Gorsuch	CDA	Although the purpose may not have been meant to determine "In addition the results are not intended to make decisions or recommend treatment practices for reducing toxic chemicals in roof runoff." it would be worth mentioning that fate and transport are important aspects of determining potential risk of the substances that are leached from roofing materials.	We concur that fate and transport are important aspects of determining potential risk. However, they have been more appropriately identified in the Recommendations section and will be part of the White Paper generated during Round 2.
7	74	Discussion, Fig. 14	Gorsuch	CDA	Change "cooper" to "copper" in figure legend.	Change made.
8	76	Discussion, first bullet	Gorsuch	CDA	Change "that" to "than" in "Runoff from our copper roof was lower in copper that those reported by Persson and Kucera (2001) in Sweden,"	Change made.
9	76	Discussion, 2nd bullet	Gorsuch	CDA	Change "cooper" to "copper" in treated with a cooper containing preservative	Change made.
10	77	Discussion Table 26	Gorsuch	CDA	Change "thi" to "this" in table title.	Change made.
11	78	Discussion Table 27	Gorsuch	CDA	A number of the "dissolved metals" were reported to exceed the total metals by 100% (one by 1620%). This raises the validity of expressing metals in this manner.	The approach to this table has been changed, and the caveats for the data are more clearly explained.
12	91	Recommendation bullet 1	Gorsuch	CDA	Glad to see that chromium monitoring in future TWO study was recommended.	While chromium was not included in Round 2 sampling, this recommendation will likely be acted upon by the Washington Stormwater Center.