More Information About The Willamette River Report Card Toxics Indicator

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DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon's air, land and water.

State of Oregon
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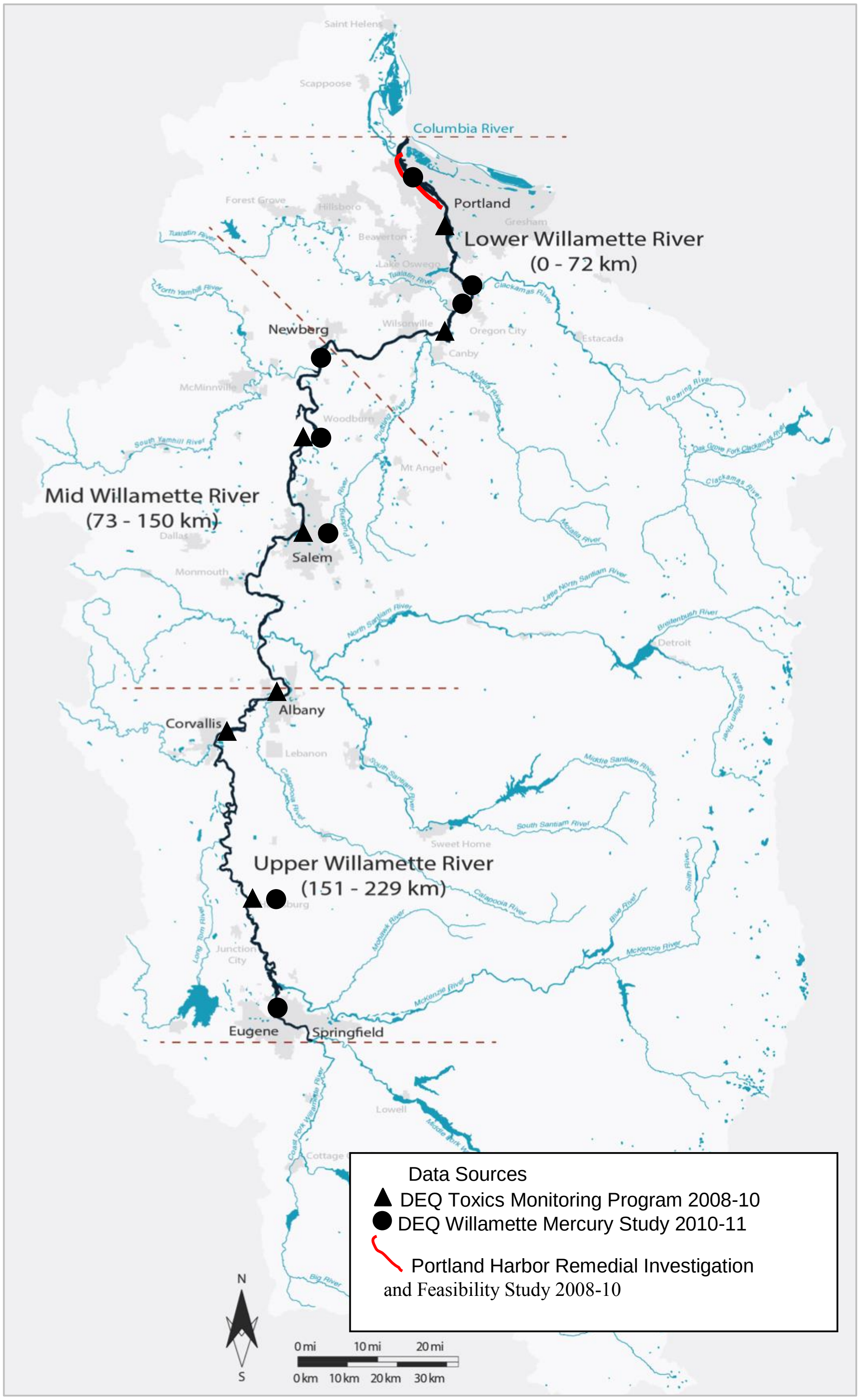

Figure 1: The Willamette River and watershed with Lower, Mid, and Upper Willamette River report card reaches. From Constanzo, et al, 2015.

Introduction:

This document provides additional background information for the toxics indicator used in the Willamette River Report Card. The complete Willamette River Report card is available at: willamettereportcard.org.

One of the strengths of the Willamette River Environmental Report Card is that it visually presents a great deal of scientific information in a non-technical format that is more accessible to managers, decision makers, stakeholders and the general public than traditional scientific reports. This strength is also one of its weaknesses in that useful information can be lost, especially for the more complex indicators such as toxics. A single, simple toxic contaminant score may not tell the whole story for most of the intended Report Card audience. For example, the toxics indicator score of 47 for the Lower Willamette River is a summarization of 38 different toxics chemicals. The score by itself doesn't tell us *which* chemicals of the 38 contaminants are problems and which are not or how these contaminants change in different parts of the river. This short report seeks to provide more detailed information to supplement the Willamette River Report Card toxics indicator while still maintaining a mostly non-technical approach.

What are 'Toxics'?

The term 'toxics' as it is used in the Report Card covers a very wide range of chemicals. Some are naturally occurring and others are man-made contaminants. They include combustion by-products, current-use pesticides, legacy or banned pesticides, certain priority metals, and polychlorinated biphenyls. All can cause impairment to aquatic life and human health. Table 1 briefly describes the groups of chemicals used in the report card. All the chemicals included in the Willamette River Report Card toxics indicator have State of Oregon criteria, EPA criteria or EPA recommended benchmarks. All were detected in the Willamette basin, either in the river's main stem or its tributaries.

The Report Card does not include a group of contaminants often called pollutants of emerging concern. These are a wide range of contaminants, including pharmaceutical substances such as synthetic birth control hormones, steroids, antibiotics, antidepressants, mood stabilizers, as well as plasticizers, industrial chemicals and many others. Some of these contaminants have been detected in the Willamette River but have no state water quality criteria or EPA recommended benchmarks. For that reason they were not included in the report card. The DEQ toxics monitoring program web site has more information on these contaminants in the Willamette River: http://www.deq.state.or.us/lab/wqm/toxics.htm.

Table 1: Chemical groups used in the Willamette River Report Card.

Chemical Group	Description	Number of compounds
Combustion by-products	These chemicals are produced by the incomplete burning of petroleum, wood and other substances. They enter the aquatic environment through deposition from the air or runoff from impervious surfaces such as road and parking lots in urban areas. Because most are not very soluble in water they tend to be found more in the sediment than in the water. It includes polycyclic aromatic hydrocarbons, a group of chemicals linked to cancer and birth defects.	4
Current-use pesticides	These are a wide range of herbicides, insecticides, and fungicides approved for use in the United States. They may enter the surface water through aerial drift or runoff from agricultural lands, public right-of-ways, managed forests, and residential property, as well as in effluent from waste water treatment facilities. The effects of low level mixtures of current use pesticides in the environment on aquatic life and human health are not well understood.	18
Priority metals	The priority metals are trace metals for which DEQ has standards for protecting aquatic life and human health. Although metals are naturally occurring, their presence in the environment can be increased through human activity. Sources of elevated metals in water include stormwater runoff, industrial processes, pesticides and consumer products. Mercury is included in this category. For example, copper can come from cars and pesticides, arsenic can come from legacy pesticides. High levels of metals can kill aquatic life but lower levels also present problems. Low copper levels in water interferes the ability of salmon and other fish to smell, impairing their ability to navigate, feed, avoid predators, and reproduce. Mercury can be released into the environment and transported great distances through the air. It tends to bio-accumulate in fish and can pose a risk to aquatic life and human health.	10
Legacy pesticides	These are chlorinated pesticides banned for most uses in the United States and many other countries due to their adverse effects to human and wildlife health. They tend to be very persistent in the environment, especially in soil and river sediment. These substances also tend to bio-accumulate in aquatic organisms presenting a risk to wildlife and humans that consume contaminated fish. They tend to have low solubility in water. Relatively few of the total possible legacy pesticides and their breakdown products were examined in this report. Future report cards based on more consistent data collection and analysis will likely include a longer list of legacy pesticides.	5
PCBs	Poly chlorinated biphenyls (PCBs) are a group of industrial chemicals that were widely used in electrical equipment such as transformers as well as many other uses. PCBs are present as more than 200 different chemical structures. The report card summarizes these as the total of all PCBs. PCB use and production is banned in the United States because of toxicity to humans and wildlife, possible links to cancer, and their environmental persistence. Like the legacy pesticides, PCBs have a low solubility in water, therefore they accumulate in the sediment and bio-accumulate in aquatic organisms.	1

Data sources:

Three data sources were used in the Toxics Indicator.

1. **DEQ Water Quality Toxics Monitoring Program**. This is data source 'X' in Table 7. In 2008, the DEQ Laboratory implemented a statewide water quality toxics

monitoring program in water, fish, and sediment samples. Seven toxics monitoring sites located within the report card reach listed in Table 2 were sampled six times in 2008-2010. Water samples were analyzed for 164 contaminants, of which 31 were detected in the Willamette Basin that have either state criteria, EPA criteria, or EPA recommended benchmark for the protection of aquatic life or human health. Data for combustion by-products, current-use pesticides and most priority pollutant metals come from this study. Mercury, PCBs and legacy pesticides were not part of this study. For more information on DEQ's Water Quality Toxics Monitoring Program see: http://www.deq.state.or.us/lab/wqm/toxics.htm.

Table 2: DEQ Water Quality Toxics monitoring stations in the Willamette River used for report card. Sample collection took place in 2008-2010. Data source 'X' in Table 7

DEQ Station ID	Site name	Willamette River Report Card reach
10611	Willamette River at Hawthorne Bridge	Lower
10339	Willamette River at Canby Ferry	Lower
10344	Willamette River at Wheatland Ferry	Mid
10555	Willamette River at Marion Street (Salem)	Mid
10350	Willamette River at Albany (eastbound Hwy 20 bridge)	Upper
10352	Willamette River at Old Hwy 34 Bridge (Corvallis)	Upper
10355	Willamette River at Hwy 99E (Harrisburg)	Upper

2. **DEQ Willamette Mercury Study 2010-2011**. This is data source 'Y' in Table 7. Mercury data used in the report card are from water samples collected four times at sixteen sites in the Willamette basin including eight sites on the Willamette River in 2010-2011 listed in Table 3. Water, sediment and fish samples were also collected. Mercury data from this study can be retrieved from the DEQ on-line data repository at http://www.deq.state.or.us/lab/lasar.htm.

Table 3: DEQ Mercury monitoring stations in the Willamette River used for the report card. Sample collection took place in 2010-2011. Data source 'Y' in Table 7.

DEQ Station ID	Site name	Willamette River Report Card reach
10821	Willamette River at St. John's Bridge	Lower
34198	Willamette River at Jon Storm Park boat dock	Lower
10833	Willamette River 0.5 miles downstream of Tualatin River	Lower
26339	Willamette River upstream of Newberg Bridge at Rogers Landing	Mid
10344	Willamette River at Wheatland Ferry	Mid
31731	Willamette River at Wallace Marine Park boat ramp	Mid
10355	Willamette River at Hwy 99E (Harrisburg)	Upper
29044	Willamette River at Greenway bike bridge, Eugene	Upper

3. **Portland Harbor Remedial Investigation and Feasibility Study.** This is data source 'Z' in Table 7. The lower portion of the Willamette River in Portland from river mile 1 to 11 was designated a Superfund site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 2000

because of heavily contaminated sediment from industrial pollution during the early 20th century. Contaminants of concern include PCBs, DDT (a legacy chlorinated pesticide), and other legacy contaminants. The Lower Willamette Group conducted extensive water monitoring for a wide range of contaminants under varying flow conditions during 2004 to 2007 as part of a remedial investigation and feasibility study for the cleanup of the Superfund site. Compared to other reaches of the Willamette River, this 10 mile long section is particularly data rich for toxics contaminants. There are data from transect samples and from spot locations. Transect concentrations were used for calculating the screening value ratio while all samples were used for the percent detections (described more in the following section). For the purposes of this report card only the data for the legacy pesticides, DDT, DDD, DDE, lindane and dieldrin, as well as the data for PCBs were used. These are important contaminants that were missing from the DEQ Toxics Monitoring Program in 2008-2010 but will be included in future monitoring. For more information on monitoring at the Portland harbor cleanup site see: http://lwgportlandharbor.org/index.htm.

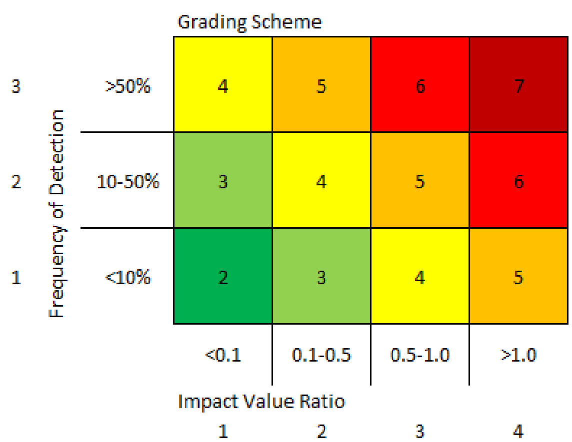

Figure 2: Toxics scoring matrix. The two sub scores (impact value ratio and frequency of detection) shown on the X and Y axis are summed to compute the toxics score. The 2 to 7 toxics score is converted into a 0-100% toxics report card grade using the equation described in Figure 3.

Scoring Calculation Method:

This section on report card scoring is from Constanzo, et al, 2015. The toxics indicator score is a combination of: i) percent of detection for combustion by-products, current-use pesticides, PCBs and legacy pesticides; or percent of detections over lowest criteria or benchmark for metals, and ii) the single highest contaminant Impact Value Ratio (i.e. highest concentration of contaminant detected in a report card reach divided by its lowest respective criterion or benchmark value) as per the toxics scoring matrix shown in Figure 2. The adopted criterion or benchmark used to calculate the Impact Value Ratio was the lowest of the state numeric criterion, the EPA Office of Pesticide Programs recommended benchmark, or other benchmark (outlined at the end of Table 7). A slightly different approach was used for scoring metals. Metals are naturally occurring in the environment as well as present through human activity. Metals were scored using the percent over criteria rather than percent detected. All other report card toxic contaminants are predominantly or exclusively the result of human activity.

The frequency of detection and the Impact Value Ratios were sub scored 1, 2, 3, or 4 using the scheme described in Figure 2, with the overall toxics score for a contaminant at a site being the sum of the two sub scores. For example, if a contaminant was found in 40% of the samples collected at a site with a maximum Impact Value Ratio of 0.6 then the score for that contaminant at that site would be 2 + 3, or 5.

The toxics score (ranging from 2 to 7) was converted to a Willamette River Report Card grade (0 to 100%) using the relationship depicted in Figure 3. Individual contaminant grades for each reach of the river were averaged for the contaminant group grades. Reach contaminant group grades were averaged for the toxics reach grade, and the three reach grades were averaged for the Willamette River grade.

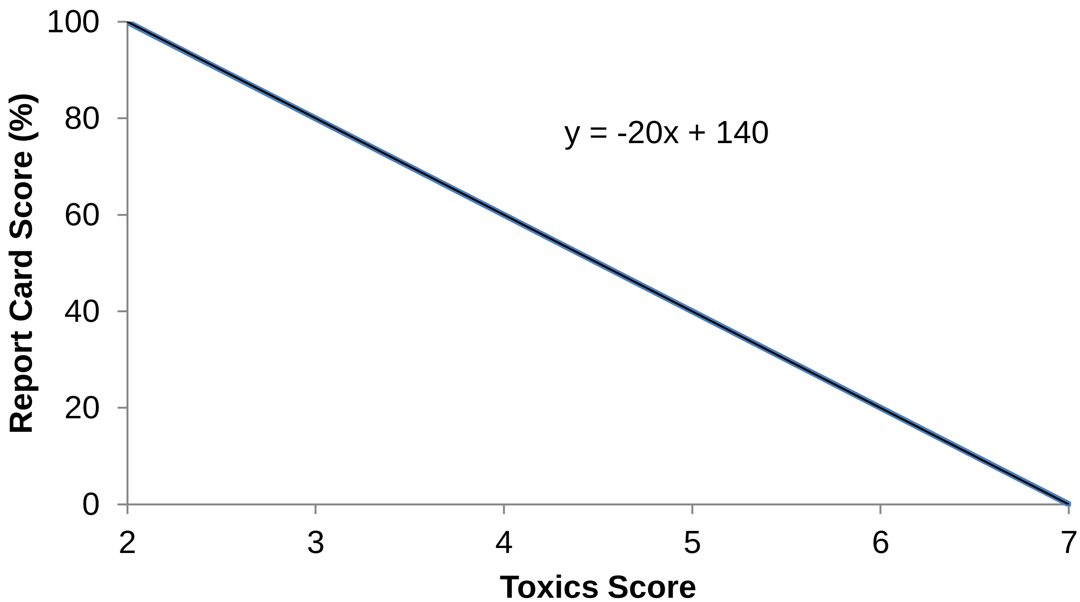

Figure 3: Relationship between toxics indicator score and report card grading system.
The toxics score derived from Figure 2 for each pollutant was transformed into the 0-100% report card grade using the conversion equation shown in Figure 3.

Results:

The number of different chemicals detected varies from the Upper to the Lower Willamette River reach with more types of chemicals detected in the lower reach (Figure 4). Priority pollutant metals and current-use pesticides were similarly detected in the three reaches with slightly more detections in the lower reach than the two upper reaches. Combustion by-products were found only in the Lower and Mid reaches. Recent PCBs and legacy pesticides data were only available for the Lower Willamette River reach which includes the heavily contaminated Superfund cleanup site from river mile 1 to 11. Although recent comparable PCBs and legacy pesticides data were not available for the other two reaches, the Mid and Upper Willamette River reaches are likely less contaminated than the Lower reach. Future monitoring in the basin will include these contaminants in all reaches of the basin.

Table 6 summarized reach scores by contaminant group and Table 7 provides a more detailed breakdown of the results by individual contaminant.

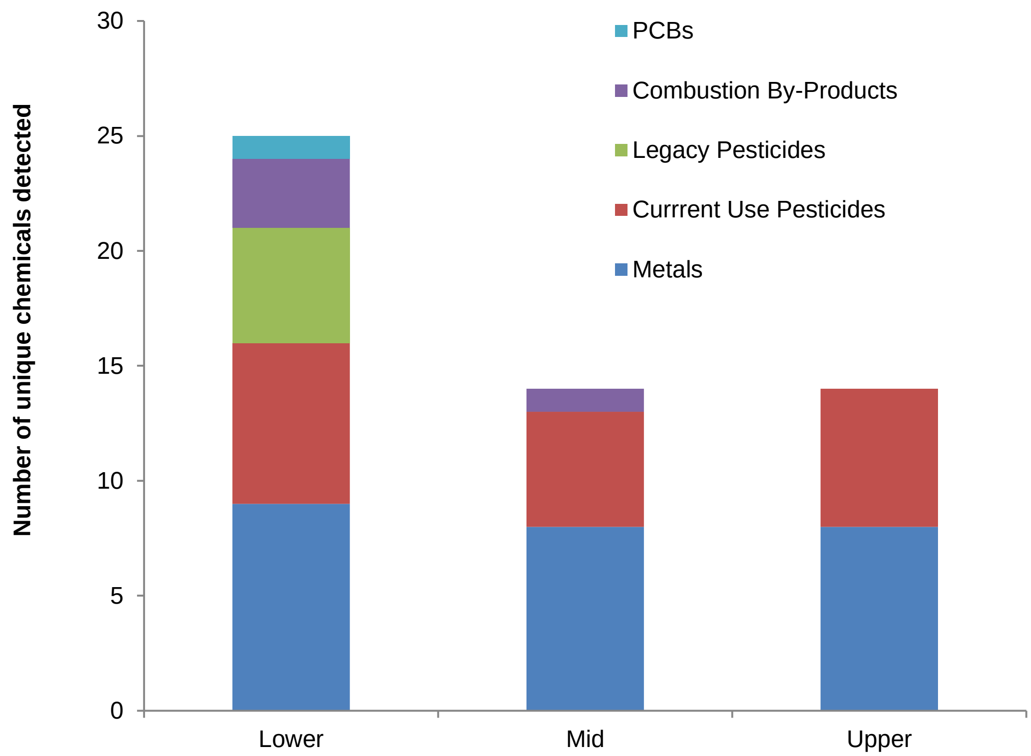

Figure 4: Number of unique chemicals detected by chemical group per Willamette River report card reach. There were insufficient data to assess PCBs and legacy pesticides in the Mid and Upper reaches.

Table 6: Scoring summary by Willamette River report card reach and chemical group.

	Lower Willamette River				Mid Willamette River				Upper Willamette River			
Toxics Category	Score (%)	Grade	Score (%)	Grade	Score (%)	Grade	Score (%)	Grade	Score (%)	Grade	Score (%)	Grade
Combustion by-products	76	B			84	A			100	A		
Current-use pesticides	88	A			93	A			93	A		
Priority Metals	62	B	47	C	71	B	83	A	67	B	87	A
PCBs	0	F				I				I		
Legacy pesticides	12	F				I				I		

Condition	Report Card Scoring System	Condition Description
A	100-80 %	Contaminants rarely found and at low concentrations relative to criteria
B	<80 - 60 %	Contaminants occasionally found but mostly at low levels relative to criteria
C	<60 - 40 %	Contaminants sometimes found at levels near the criteria
D	<40 - 20 %	Contaminants frequently found at high concentrations relative to criteria
F	<20 %	Contaminants very frequently found and at high concentrations relative to criteria
I	none	Insufficient data for evaluation.

Lower Willamette reach:

The Lower Willamette report card reach received an overall toxics indicator score of 47, the lowest of the three reaches, mostly because of the historic contamination associated with Portland harbor. If data from the Portland harbor were excluded the Lower reach would score only slightly lower than the Mid and Upper reaches.

Four of the five combustion by-products were found in the Lower Willamette at the Canby site (DEQ site # 10339) with two chemicals, benzo(b)fluoranthene and chrysene, found at high concentrations over the state criteria for human health protection.

Seven out of eighteen current-use pesticides were found in the Lower Willamette, slightly more than the other two reaches. Diuron, simazine, atrazine, pentachlorophenol and prometon were commonly found in 30% or more of the samples with diuron found in 100% of the samples. Diuron, simazine and atrazine are all herbicides with similar mechanisms of toxicity. Prometon is an herbicide used in non-crop applications to control broadleaf weeds, brush and grass. Pentachlorophenol is an organochlorine chemical used as a wood preservative, insecticide, herbicide, fungicide and algaecide. Although most pesticides were found in fairly low concentrations relative to criterion to protect human health and aquatic life, pentachlorophenol was found 2.2 times over the criterion for the protection of human health.

Overall, the Lower Willamette reach scored poorly for priority pollutant metals. Copper, iron, lead and zinc were all present near or above their respective criteria for the protection of aquatic life. In particular, copper was found as high as 17 times the aquatic life criterion, the highest toxic metal criterion exceedances found in this assessment. Iron, lead and zinc were also found at levels near or above their criteria.

The Lower Willamette reach scored poorly for PCBs and legacy pesticides reflecting the heavily contaminated Portland harbor cleanup site in this reach.

Mid Willamette reach:

A single combustion by-product, indeno(1,2,3-cd) pyrene, was found at one out of ten samples collected at the Wheatland site (DEQ site # 10344) at a level more than 15 times the state criterion for the protection of human health.

Current-use pesticides found in the Mid Willamette reach included diuron, atrazine, simazine, oxamyl, and metribuzin with diuron found in 60% of the samples collected in this reach. Concentrations tended to be fairly low with none exceeding the associated benchmarks.

Copper, iron and lead contamination in the Mid Willamette are problems similar to the other two reaches. These three metals were found at more than half of the sites with levels as high as 2.5 times the criterion.

PCBs and legacy pesticides were not assessed in the Mid Willamette River because of lack of recent data comparable with data in the Lower Willamette.

Upper Willamette Reach:

No combustion by-products were found in the Upper Willamette Reach.

As in the Lower and Mid reaches, diuron was the most widely found current-use pesticide in the Upper reach, with it being detected in 50% of the samples, followed by atrazine, simazine, pentachlorophenol, metribuzin and metolachlor. All detections were fairly low relative to criteria except pentachlorophenol which was detected at 90% of the criterion.

Overall metals score indicates the Upper reach to be intermediate between the Mid and Lower Willamette River reaches. Copper, lead and iron were all extensively found at levels 1 to almost 3 times over the criterion. Zinc and mercury were also extensively found but at levels below the criterion.

PCBs and legacy pesticides were not assessed in the Upper Willamette River because of lack of recent data comparable with data in the Lower Willamette.

Table 7. Toxics indicator scoring by individual parameter, parameter group, and assessment reach.

Willamette River: 72 B				Lower: 47 C						Mid: 83 A						Upper: 87 A					
Analyte (Units)	Data source	Criterion/ Benchmark	Criterion source	Number of samples	Percent detects	Max value	Max SVR	Score	Grade	Number of samples	Percent detects	Max value	Max SVR	Score	Grade	Number of samples	Percent detects	Max value	Max SVR	Score	Grade
Combustion By-Products (ng/L)								76	B					84	A					100	A
Benzo(b)fluoranthene	X	1.3	1	12	8	33	25.38	40	C	10	0	0	0.00	100	A	18	0	n	0.00	100	A
Chrysene	X	1.3	1	12	8	26	20.00	40	C	10	0	0	0.00	100	A	18	0	n	0.00	100	A
Fluoranthene	X	14,000	1	12	8	34	0.00	100	A	10	0	0	0.00	100	A	18	0	n	0.00	100	A
Indeno(1,2,3-cd)pyrene	X	1.3	1	12	0	n	0.00	100	A	10	10	20	15.38	20	D	18	0	n	0.00	100	A
Pyrene	X	290,000	1	12	8	28	0.00	100	A	10	0	0	0.00	100	A	18	0	n	0.00	100	A
Current Use Pesticides (ng/L)								87	A					93	A					93	A
2,4-D	X	100	1	12	0	n	0.00	100	A	10	0	n	0.00	100	A	18	0	n	0.00	100	A
Atrazine	X	1,000	2	12	33	27.9	0.03	80	A	10	20	8.6	0.01	80	A	18	22	58.9	0.06	80	A
Carbaryl	X	500	3	12	0	n	0.00	100	A	10	0	n	0.00	100	A	18	0	n	0.00	100	A
Carbofuran	X	750	3	12	8	2.6	0.00	100	A	10	0	n	0.00	100	A	18	0	n	0.00	100	A
Dicamba	X	61	4	12	0	n	0.00	100	A	10	0	n	0.00	100	A	18	0	n	0.00	100	A
Diuron	X	2,400	4	12	100	329	0.14	40	C	10	60	272	0.11	60	B	18	50	140	0.06	80	A
Hexazinone	X	7,000	4	12	0	n	0.00	100	A	10	0	n	0.00	100	A	18	6	148	0.02	100	A
Imidacloprid	X	1,050	3	10	0	n	0.00	100	A	10	0	n	0.00	100	A	15	0	n	0.00	100	A
Metolachlor	X	1,000	3	12	8	24.1	0.02	100	A	10	0	n	0.00	100	A	18	6	17.9	0.02	100	A
Metribuzin	X	8,700	4	12	16	6.2	0.00	80	A	10	10	4.3	0.00	80	A	18	6	5.3	0.00	100	A
Norflurazon	X	9,700	4	12	17	n	0.00	80	A	10	0	n	0.00	100	A	18	0	n	0.00	100	A
Oxamyl	X	27,000	3	10	0	n	0.00	100	A	10	10	51.9	0.00	80	A	15	0	n	0.00	100	A
Pentachlorophenol	X	150	1	10	30	330	2.20	20	D	8	0	n	0.00	100	A	15	13	135	0.90	40	C
Prometon	X	98,000	4	10	30	n	0.00	80	A	10	0	n	0.00	100	A	15	0	n	0.00	100	A
Propiconazole	X	21,000	4	10	0	n	0.00	100	A	10	0	n	0.00	100	A	18	0	n	0.00	100	A
Pyraclostrobin	X	1,500	4	12	0	n	0.00	100	A	10	0	n	0.00	100	A	18	0	n	0.00	100	A
Simazine	X	2,240	4	12	50	102	0.05	80	A	10	20	30	0.01	80	A	18	17	47	0.02	80	A
Triclopyr	X	100	4	12	0	n	0.00	100	A	10	0	n	0.00	100	A	18	0	n	0.00	100	A
Priority Metals (µg/L)					Percent > criterion			62	B		Percent > criterion			71	B		Percent > criterion			67	B
Arsenic	X	2.1	1	42	0	0.38	0.18	80	A	33	0	n	0.00	100	A	64	0	n	0.00	100	A
Barium	X	1,000	1	42	0	31.5	0.03	100	A	33	0	19.6	0.02	100	A	64	0	23.1	0.02	100	A
Chromium	X	11	5	42	1	3.8	0.35	80	A	33	0	4.2	0.38	80	B	64	0	3.5	0.32	80	B
Copper	X	HB	6	42	7	64.3	17.08	40	C	33	3	4.2	1.16	40	C	64	8	4.7	1.30	40	C
Iron	X	1000	7	42	10	4470	4.47	20	D	33	9	2580	2.58	40	C	64	14	2870	2.87	20	D
Lead	X	HB	6	42	14	1.62	2.84	20	D	33	9	1	1.85	40	C	64	20	1.27	2.35	20	D
Mercury	Y	0.012	7	12	0	0	0.29	80	A	12	0	0	0.27	80	B	12	0	0	0.30	80	B
Nickel	X	HB	6	42	0	3.5	0.22	80	A	33	0	3.3	0.21	80	B	64	0	2.9	0.18	80	B
Zinc	X	HB	6	42	0	37.6	0.99	60	B	33	1	14.8	0.41	80	B	64	0	13.7	0.38	80	B
PCBs (ug/L)								0	F						I						I
Total PCBs	Z	6.4E-06	1	307	99	0	201.60	0	F												
Legacy pesticide (ug/L)								12	F						I						I
4,4 DDD	Z	0.000031	1	292	74	0	39.70	0	F												
4,4 DDE	Z	0.000022	1	301	71	0	92.70	0	F												
4,4 DDT	Z	0.000022	1	307	73	0	86.40	0	F												
Dieldrin	Z	5.3E-06	1	269	65	0	72.50	0	F												
Lindane	Z	0.08	7	296	59	0	0.00	60	B												

Table 7, continued. Codes:

Abbreviations:

HB: Hardness based metals criterion. Table 30 - Aquatic Life Water Quality Criteria,. www.deq.state.or.us/wq/standards/docs/tables303140.pdf

Max SVR: the Maximum Screening Value Ratio is the highest concentration (Max value) found in the reach divided by the lowest criteria or benchmark for that contaminant.

n: not detected. Criterion is greater than method detection limit.

n*: not detected. Criterion is less than method detection limit. Although sites with no detections are given good scores in the report card, this is only an estimate for these contaminants since the true condition relative to the criterion is not known. The site could receive a lower score if the analytical method allowed detection at the criterion.

Criterion/Benchmarks Sources:

1. Table 40 - Human Health Water Quality Criteria for Toxic Pollutants. www.deq.state.or.us/wq/standards/docs/tables303140.pdf.

2. Oregon and other reach 10 States are currently evaluating the EPA's recommended Atrazine benchmark of 1 ng/L. Until then, Oregon will continue to use 1,000 ng/L to evaluate Atrazine until a regionally uniform approach has been adopted.

3. EPA office of pesticide programs, invertebrate, chronic. www.epa.gov/oppefed1/ecorisk_ders/aquatic_life_benchmark.htm.

4. EPA office of pesticide programs, non vascular plants, acute. www.epa.gov/oppefed1/ecorisk_ders/aquatic_life_benchmark.htm.

5. EPA office of pesticide program, vascular plants, acute. www.epa.gov/oppefed1/ecorisk_ders/aquatic_life_benchmark.htm.

6. Table 30 - Aquatic Life Water Quality Criteria, Hardness based. www.deq.state.or.us/wq/standards/docs/tables303140.pdf.

7. Table 30 - Aquatic Life Water Quality Criteria, Chronic criteria. www.deq.state.or.us/wq/standards/docs/tables303140.pdf

Data Sources

X: DEQ Toxics Monitoring Program, Willamette Basin, 2008-2010, see Table 3-3 for sites. http://www.deq.state.or.us/lab/wqm/toxics.htm.

Y: DEQ Willamette Basin Mercury Study, 2010-2011, see Table 3-4 for sites. http://www.deq.state.or.us/lab/lasar.htm.

Z: Lower Willamette Group, August 29, 2011, Portland Harbor RI/FS Remedial Investigation Report, samples collected in 2004-2007, Transect water samples in high flow, low flow and storm influenced flow conditions. See Lower Willamette Group report for sites information. http://lwgportlandharbor.org/index.htm.

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Constanzo, Simon, Heath Kelsey, and Tracey Saxby. 2015. Willamette River Report Card: Scores and Scoring Methodology. Integration and Application Network, University of Maryland center for Environmental Science. willamettereportcard.org.

Oregon Department of Environmental Quality. 2015. Statewide Water Quality Toxics Assessment Report. Oregon Department of Environmental Quality, Laboratory and Environmental Assessment Program, 3150 NW 229th Ave, Suite 150, Hillsboro, OR 97124. DEQ15-LAB-0065-TR. http://www.deq.state.or.us/lab/wqm/toxics.htm.