Green Chemistry Webinar Series for HS Teachers:

Safer Chemistry: Drop-in Replacement Labs

11/13/13

Kate Anderson
Director of Education
Beyond Benign
Wilmington, MA

Ann Lambert
High School Chemistry Teacher
King Phillip High School
Wrentham, MA

- Visit the WA State Department of Ecology Green Chemistry pages:

http://www.ecy.wa.gov/programs/hwtr/P2/GreenChem/greenchem_ecy.html
http://www.ecy.wa.gov/programs/hwtr/p2/GreenChem/Greenchem_resources.html

- Participate by asking questions during the webinar and providing feedback with the follow-up survey

- WA State teachers will receive 1 clock hour for attending & participating in this webinars. Please contact Saskia van Bergen :

Saskia.vanBergen@ecy.wa.gov by 11/14/13

beyondbenign
green chemistry education

MISSION AND VISION

Beyond Benign is dedicated to providing future and current scientists, educators and citizens with the tools to teach and learn about green chemistry in order to create a sustainable future.

Beyond Benign's vision is to revolutionize the way chemistry is taught to better prepare students to engage with their world while connecting chemistry, human health and the environment.




Program areas:

K-12

- Curriculum Development and Teacher Training
  - Green Chemistry
  - Green Math & Engineering
  - Biotechnology
- On-line Courses
- Professional Development Workshops
- K-12 and Community Outreach
- College Student Fellows program

College/University

- The Green Chemistry Commitment
- Curriculum Development and Training
  - Technical Training
  - Green Chemistry training for workers
  - Green Chemistry tools

Green Chemistry HS Curriculum

3 types of lesson plans:

Type 1: What is Green Chemistry?

- Introduces students to the concepts of green chemistry

Type 2: Green Chemistry in Industry

- Learn about chemistry within context
- All lessons are linked to state and national learning standards

Type 3: Green Chemistry Replacement Laboratory Exercises

- Drop-in replacements
- Eliminates or reduces the use of hazardous chemicals in the classroom
- Linked to state and national learning standards

Available for download free-of-charge at: www.beyondbenign.org
Direct link: http://www.beyondbenign.org/K12education/highschool.html

Green Chemistry is

"the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the **design**, manufacture and application of chemical products"

- The science of making things
- The science of innovation & invention
- The science of **solutions**

*Anastas, P.T.; Warner, J.C., Green Chemistry: Theory and Practice, Oxford University Press, 1998.

Is there a need for drop-in replacement labs?

Risk = Exposure x Hazard

- Lab Safety focuses on Exposure
  - Keeping students safe in lab (PPE, eye wash stations, showers, etc)
  - Lab protocols
  - Proper chemical storage
  - Proper disposal of hazardous materials

Green chemistry addresses the Hazard

- Keeping students safe in lab by limiting/ eliminating the hazardous chemicals used in the lab.
- Challenging students to question lab protocols (are we using the safest materials we can?)
- Preventing the creation of hazardous waste in the first place
- Reducing costs associated with ordering, transporting and storing hazardous chemicals
- Many more considerations

Example of an Exothermic Reaction Demo

- http://www.youtube.com/watch?v=pqi50sjJVc0&feature=related

Hazards Associated with Dehydration of Sugar

- Concentrated Sulfuric Acid
  - Health Hazard 3 (Known carcinogen)
  - Corrosive
  - Reactive (reacts with water)
  - Oxidizer
- Sulfur Dioxide
  - Health Hazard 3 (Inhalation Risk)

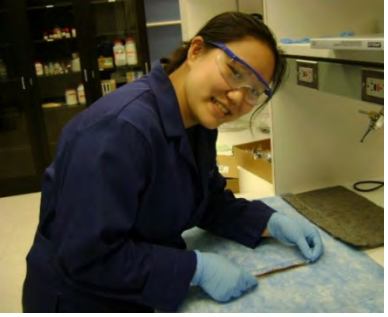
Exothermic and Endothermic

- How do we commonly teach these concepts?
- Common combinations:
  - Ammonium nitrate & barium hydroxide
  - Magnesium metal & hydrochloric acid
- Safety Considerations
  - Disposal challenges
  - Spill threat
  - Corrosive acid
  - Flammability
  - Noxious gas

Exothermic and Endothermic

- How can we teach the same concept in a safer way?
- Exothermic Reaction Replacement
  - Introduce catalase (enzyme-beef liver)
  - 6% Hydrogen peroxide
  - Relight burning splint (evidence of oxygen being given off)
- Endothermic Reaction Replacement
  - Citric acid (pixie stick)
  - Water

http://www.beyondbenign.org/K12education/highschool.html



Curriculum Mapping

-How to guide for integrating green chemistry into a year long chemistry course

-Multiple resources listed

-Links to videos, demos, lessons, etc.

-ACS Green Chemistry Institute, University of Scranton, Royal Society of Chemistry

Snapshot of Curriculum Mapping

3. Matter

- "A small dose of Toxicology" – Steven Gilbert, this is a book and will be most useful to teachers not students. *This website also contains teacher resources although none of them are really activities but rather a wealth of background information.*

http://www.asmalldoseof.org/

- ▪"Environmental Impact Factor" - Beyond Benign. *This lesson is to introduce the concept of e- factor and how it can be used to evaluate matter.*

- "Sea-nine 211 – industry example" Beyond Benign. *This lesson highlights presidential green chemistry award winning technology, Sea-nine 211which is an anti-foulant made by Rohm and Haas and is used to coat the hulls of ships in or to prevent barnacles and sea debris from adhering and creating drag. This technology replaced previously used substances that were known to bioaccumulate and create pollution in the oceans. The lesson includes a PowerPoint which introduces the new technology and a lab component that looks at toxicity through an LD- 50 lab and the connection of chemicals and living organisms. The lesson can be used to teach bioassays, bioaccumulation and serial dilutions.*

- ▪"Sublimation" Beyond Benign. *This lab replaces the traditional naphthalene sublimation lab. Students will observe sublimation (physical properties of matter) and explain the type of change that occurred. This lesson also reinforces temp measuring and mass measuring etc.*

Green Chemistry Replacement Labs

aka...Talking the Talk
AND
Walking the Walk

My Road to a Greener Lab

- 2009 ChemEd – attended Beyond Benign workshop
- 2010 – summer workshop at Beyond Benign
- 2011 – curriculum work to develop new replacement labs

My Advice for a Greener Lab

- Take a little at a time
- Work to understand the difference between Green and Green(er)
  - Any change is worthwhile!
- Involve your students in the process
- Get your colleagues on board

Reaction Lab

- Single displacement
- Double displacement
- Composition (Synthesis)
- Decomposition

http://www.beyondbenign.org/K12education/highschool.html

Single Displacement

- Which is greener/safer?
  - Mg with $CuCl_2$
  - Zn with HCl

Single Displacement

- Which is greener/safer?
  - Zn with HCl

Why?

- Criteria for choosing the procedure used:
  - Zinc is safer than magnesium (especially if you are using a nail). Hydrochloric acid in dilute solutions **is safer.**
- Green Chemistry Principle that guided your choice
  - #3, less hazardous chemical synthesis; #12, accident prevention (no Mg)

Double Displacement

- Which is greener/safer?
  - $CuSO_4$ with K_2CO_3
  - $Na_2C_2O_4$ with $CaCl_2$

Double Displacement

- Which is greener/safer?
  - $CuSO_4$ with K_2CO_3

Why?

- Criteria for choosing the procedure used:
  - Sodium oxalate is toxic to humans
- Green Chemistry Principle that guided your choice
  - #3, less hazardous chemical synthesis

Composition (Synthesis)

- CaO with H_2O
- Cu wire and a Bunsen burner
- Could there be other choices.....?

Composition (Synthesis)

- Cu wire and a Bunsen burner
- Could there be other choices.....?

Why?

- Criteria for choosing the procedure used:
  - Calcium oxide causes burns, is hazardous and reacts violently with water (which can cause enough heat to ignite combustible materials).
  - Ours still uses a Bunsen burner (energy intensive), but seems like a better alternative
- Green Chemistry Principle that guided your choice
  - #3, less hazardous chemical synthesis; #12, accident prevention

Decomposition

- H_2O_2 with a Potato
- $CaCO_3$ and a Bunsen burner

Decomposition

- H_2O_2 with a Potato

Why?

- Criteria for choosing the procedure used:
  - Use of a catalyst in #5 is good. Hydrogen peroxide is dilute solution.
  - Since this choice is safe AND is conducted at ambient temperatures it is the greener choice
- Green Chemistry Principle that guided your choice
  - #6, Energy Efficiency; #7, use of renewable feedstocks (potato); #8, catalysis (potato); #9, design for degradation (potato will degrade)

Reactions Lab

- Students decide between these choices, then after teacher approval (making sure they picked the best one) they conduct experiments
- Classes too large? This works great as a demo with more student involvement by using the lab sheet in advance and students pick the greener choice

Educational Goals of this Lab

Students will understand…

- How to distinguish between a single displacement, double displacement, composition and decomposition reaction
- How to observe reactions and predict the product
- How to critique chemical reactions using the 12 principles of green chemistry and compare their hazards

Teacher Friendly Materials on Website

- Docs are in Word and all editable!
- Includes:
  - Teacher background info
  - Safety info
  - Materials
  - Time required
  - Standards met
  - Teacher prep instructions
  - Teachers answer keys to student handouts

Student Handouts

- Pre-lab worksheet
  - Practice the four types of reactions
  - Decide on the best of each type (includes a table to explain choice)
  - Supplemental info sheet on chemicals (to make choices)
- Lab instruction sheet
- Data collection worksheet with discussion questions

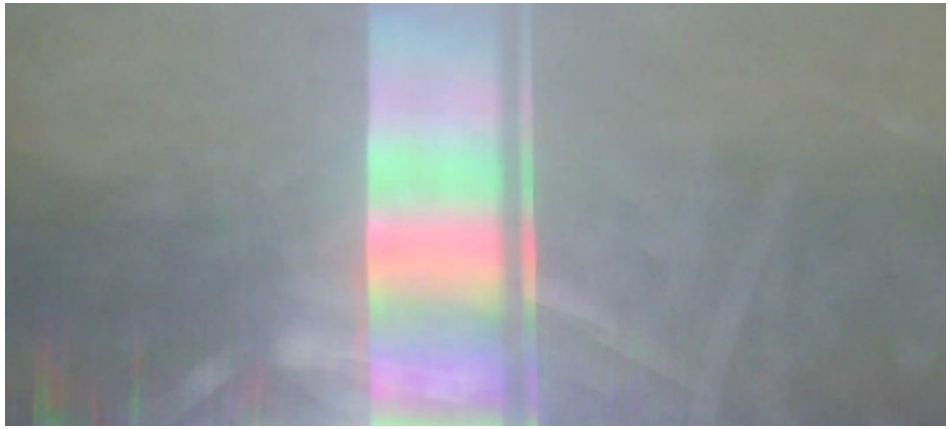
Flame Test

- What's not green about the typical flame emission test?
  - Use solutions of toxic metal salts
  - Use Bunsen burners (safety)
  - Use Bunsen burners (a lot of energy used)
  - Even when used on microscale the metal ions in the salt solutions become volatized

A Greener Flame Test Lab

- Use colored birthday candles
  - Lower temps
  - Less energy expended
  - Fewer volatized metal atoms
  - Able to actually see the spectral lines using diffraction paper
  - More inquiry!

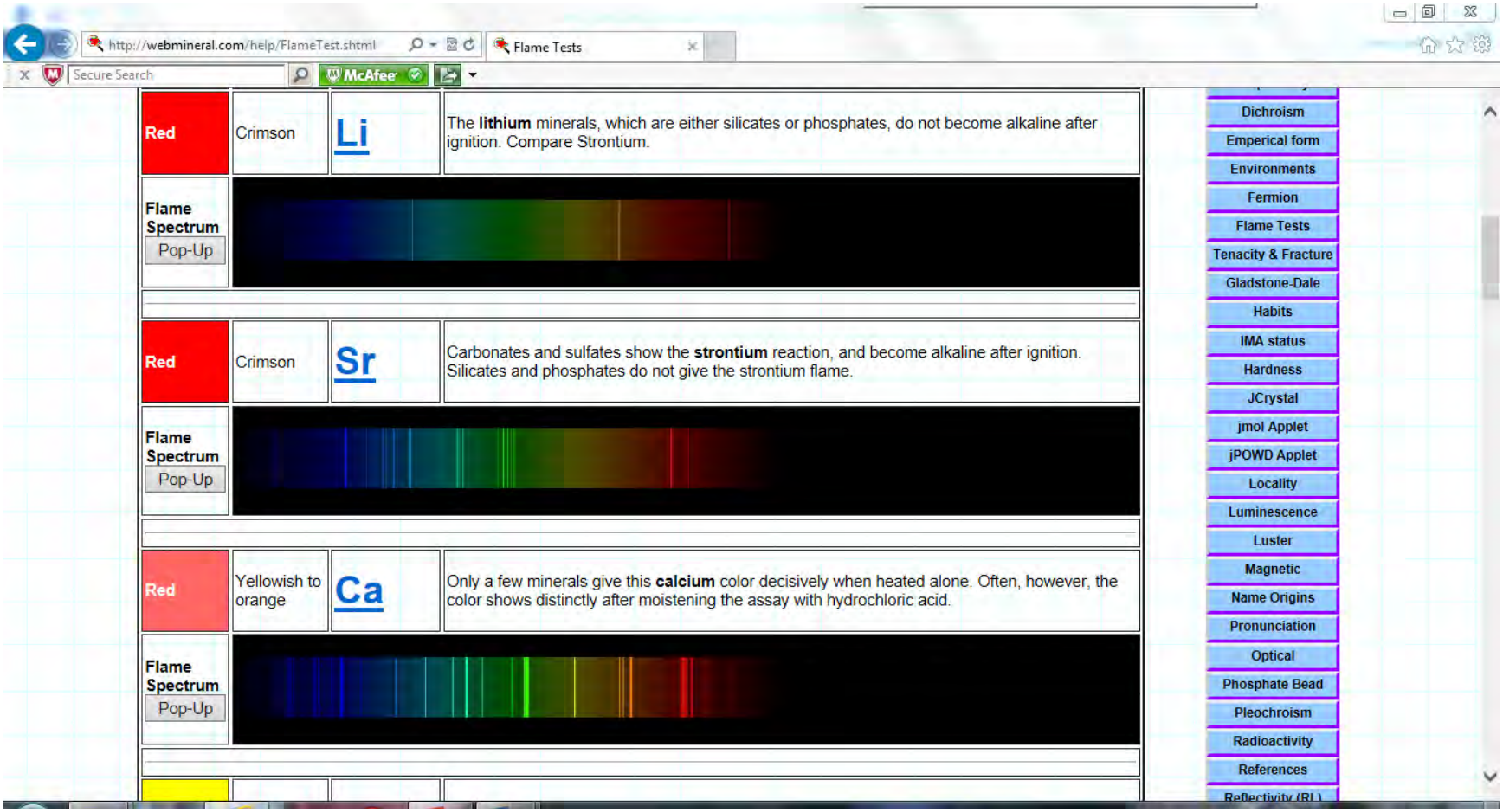
http://www.beyondbenign.org/K12education/highschool.html



Students can actually view the spectra using diffraction film!

- Printouts of emission spectra are available from a variety of sources – one student-friendly website is http://webmineral.com/help/FlameTest.shtml
- Unlike a traditional flame lab where students quickly glimpse an overall color in a Bunsen burner, students can actually identify a substance based on the emission spectra

Webmineral website clip



Using the website

- Students should first narrow down their search by categorizing the flame color to the naked eye
- Once they narrow down the identification, they should use the diffraction film to make an identification
- The objective is for the student to support their identification by matching the spectrum they see to the one published.

Flame Test Lab

- Student experiences
  - Inquiry
  - engaged
- Cost?
  - Candles packages can be found at a variety of stores
  - Usually under $2.00 per box, which has two sets of colors

Educational Goals

- Students will understand…
  - That each element has a unique emission spectrum
  - How to identify the presence of an element using its emission spectrum

Student Objectives

- Students will…
  - Observe a colored flame with the naked eye
  - Use diffraction grating film or a spectroscope to identify the emission spectrum of each flame
  - Match the emission spectrum to an element using an emission spectra chart

Materials Online

- Same format as the Reaction Lab
- All editable in Word format

Equilibrium/LeChatlier's Principle

Traditionally, equilibrium experiments and Le Chatelier's Principle are illustrated using the following experiments:

(A) $CoCl_4^{2-}$ + $6H_2O$ $\overset{\text{exo}}{\underset{\text{endo}}{\rightleftharpoons}}$ $Co(H_2O)_6^{2+}$ + $4Cl^-$

blue red

This experiment is used to demonstrate the effects of both temperature changes and concentration changes on an equilibrium mixture.

(B) $Cr_2O_7^{2-}$ + H_2O $\rightleftharpoons$ $2CrO_4^{2-}$ + $2H^+$

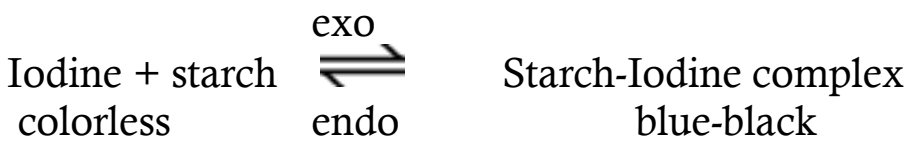
orange yellow

This experiment is used to demonstrate the effects of concentration changes on an equilibrium mixture.

(C) Fe^{3+} + CNS^- $\rightleftharpoons$ $Fe(CNS)^{2+}$

yellow red

Replacement Reactions



Student Objectives

- At the end of this lesson, students will be able to:
  - Explain the concept of chemical equilibrium.
  - Distinguish between static and dynamic equilibrium.
  - State Le Chatelier's Principle.
  - Describe how to set up an experiment that is at chemical equilibrium.
  - Predict the effect of adding a stress to the system at equilibrium.

Online Video

http://www.beyondbenign.org/K12education/highschool.html

		Connections to Framework and/or NGSS		
Replacement Lab	**Lab's Educational Goals**	**Science & Engineering Practices**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Reaction lab	How to distinguish between a single/double displacement, composition and decomposition reaction		Supports HS-PS1.B	
	How to observe reactions and predict the product	P2: Dev. models to predict	Supports HS-PS1.B	1. Patterns
	How to critique chemical reactions using the 12 principles of green chemistry and compare their hazards	P1: Asking questions… P6: Constructing Explain. P7: Argue from Evidence…		4. Systems
Flame Tests…	That each element has a unique emission spectrum		HS-PS4.A Wave Prop.	6. Structure & Function
	How to identify the presence of an element using its emission spectrum	P6: Constructing Explanations		
Equilibrium…	Explain the concept of chemical equilibrium.		HS-PS1.B Chem Rxn	7. Stability & Change
	Distinguish between static and dynamic equilibrium.		HS-PS1.B Chem Rxn	
	Describe how to set up an experiment that is at chemical equilibrium.	P3: Plan Investigations	HS-PS1.B Chem Rxn	
	Predict the effect of adding a stress to the system at equilibrium.	P2: Dev. models to predict P7: Argue from		7. Stability & Change

Student Development of Replacement Labs

- Applications of Equilibrium lab
- Acid/base titration using natural indicators
- Hydrogel beads
- Electrochemical Cell
- Empirical formula of iron oxide

Information to Handle waste/Pollution Prevention

Identify and Designate Waste

http://www.ecy.wa.gov/programs/hwtr/manage_waste/identify_waste.html

Example resources: Waste Designation Tool, Categories of Dangerous Waste

Pollution Prevention Resources for Schools and Laboratories

http://www.ecy.wa.gov/programs/hwtr/P2/schoolsAndLabs/Index.html

King County Rehab the Lab

http://www.lhwmp.org/home/educators/rehabthelab.aspx

Example resources: School Chemicals list, Laboratory waste management guide, Safety videos

Disposal Video http://www.lhwmp.org/home/educators/labvideos.aspx

Chemical Hygiene/Management

Waddell's 2014 Chemical Hygiene Trainings.

http://www.lhwmp.org/home/educators/science-workshops.aspx

Recorded Webinar- EPA region 10

Current Issues in Chemical Management: Best Practices for Schools and Districts

Not yet posted but will probably be at:

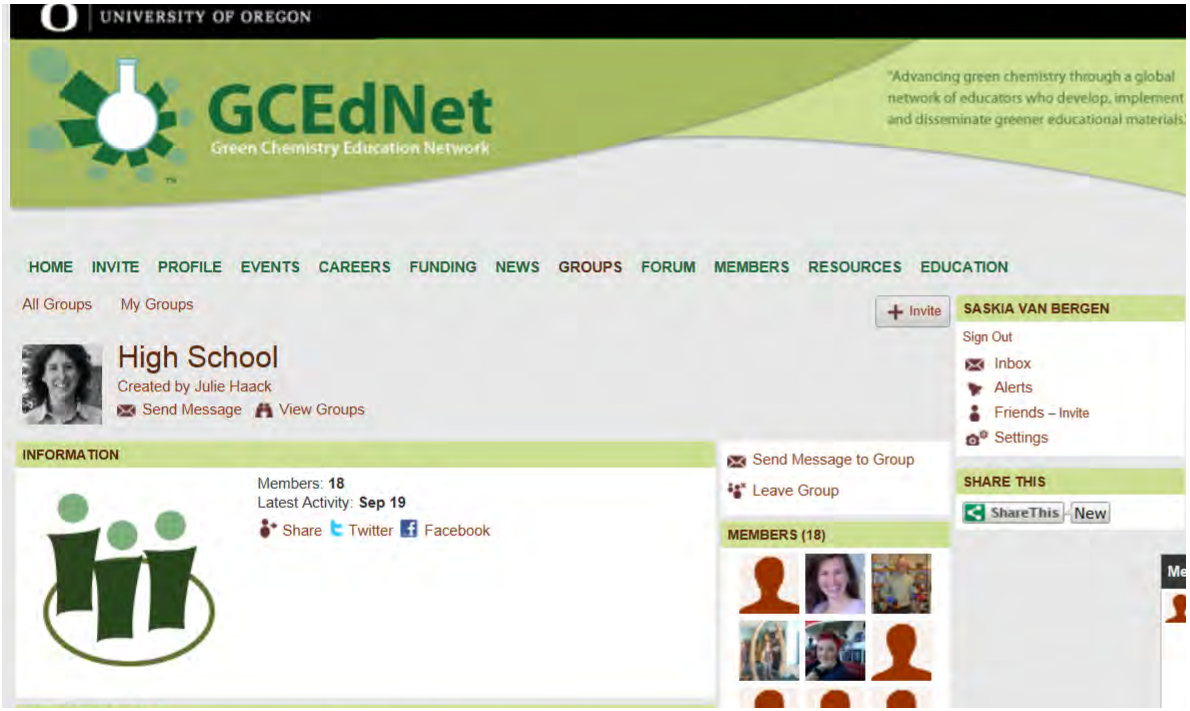
http://yosemite.epa.gov/R10/ecocomm.nsf/childrenshealth/sensible-steps-webinars

Network of Teachers

Green Chemistry Education Network (GCEdNet)

High School Group http://cmetim.ning.com/group/highschool

Discussion forum



QUESTIONS

Thank you!

Please provide feedback through the follow-up survey.

Reminder:

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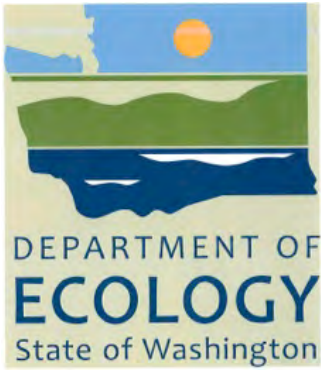

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