MEMORANDUM | May 21, 2012

TO Hanford Natural Resource Trustee Council

FROM Nadia Martin, Industrial Economics, Inc. and Dale Engstrom (Oregon)

SUBJECT Summary of Expert Panel: Characterizing the Nature and Extent of Contaminant Upwellings in the Columbia River for Purposes of Natural Resource Injury Assessment

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This memorandum provides a summary of the discussion and recommendations from the Hanford Upwellings Expert Panel, held in Richland on Friday, May 4, 2012 from 9 am to 4 pm in room 142 of the Federal Building. The panel agenda is provided as Appendix A, the charge memorandum as Appendix B, and the presentations given during the panel as Appendices C-E. The memorandum is organized into two main sections: section 1, the executive summary, which provides a brief description of the panelists, attendees, and main recommendations; and section 2, the discussion section, which provides a more detailed description of the panel discussions.

SECTION 1 EXECUTIVE SUMMARY

The discussion began with some introductory remarks from Dale Engstrom, and presentations from Dr. Woessner regarding the 2008 panel and from Mr. Tiller and Dr. Peterson on their past work related to contaminant upwelling at Hanford. Following the presentations, the panelists discussed the charge questions and ended with their final recommendations for the HNRTC.

The main discussion points and recommendations from the panel included:

- When studying contaminant upwelling in the Hanford Reach, an important first step is to narrow the scope of the assessment. Potential methods for limiting assessment area include: 1) determining the extent of contamination surrounding operable areas and limiting assessment to those areas; 2) characterizing opposing groundwater masses using geochemical differences to separate out the groundwater coming from the non-Hanford side, and limiting assessment to the area affected by Hanford releases; or, 3) using simulation models to tease out important variables and use that information to extrapolate to other areas of the river. Another way to limit the investigation is to determine where there is *not* injury and focus on areas of potential injury
- There is an abundance of data at Hanford including hydrodynamic flow modeling, water table data, bathymetric data, LIDAR river bottom data, geophysics, fiber-optic cable temperature data, towed camera video information, Trident probe data, and biota sampling data. A careful review of all available information may help to identify possible ways of re-interpreting information to benefit the Injury Assessment Plan.
- Further develop the use of the Trident probe; particularly the semi-permanent probe system in order to obtain temporal contaminant data (i.e., sediment and water samples for analysis) in addition to the groundwater conductance data

typically obtained using the Trident probe. In addition, taking deeper samples with the Trident probe may also be useful, since deeper samples will likely be stronger (less mixed) with a high concentration of upwelled groundwater.

- When designing a study, some recommendations included:
    - Using a geo-statistical sampling grid to determine density of upwelling sites.
    - Size of area of upwelling should be known to help drive the size of sampling grid cells.
    - Important to tie any sampling plan to the relationship between upwelling sites and the geomorphology of the river.
    - Some key sites to study (i.e., sites that are likely to provide sufficient data to extrapolate to the rest of the river) include the 100-H, 100-D, and the 300 area.
- Lastly, the panelists recommended focusing on the end goal when designing a study or characterizing upwelling in the Reach (i.e., to determine what upwelling data are needed to characterize injury to aquatic biota). One recommendation was to install the semi-permanent sampler in un-occupied salmon redds, in order to be able to take readings later when the fish are there. The panelists and Trustees came to the conclusion that focusing on how upwellings may injure aquatic biota could be beneficial when designing an upwellings study; and hence, it will be important to collaborate with the Aquatic Technical Working Group in the future.

ATTENDEES

The following panelists participated in the Hanford Expert Panel entitled Characterizing the Nature and Extent of Contaminant Upwellings in the Columbia River for Purposes of Natural Resource Injury Assessment:

- Dr. William Woessner (University of Montana)
- Dr. Gary Johnson (University of Idaho)
- Mr. Brett Tiller (EAS)
- Dr. Robert Peterson (PNNL)

In addition, the panel was organized by Nadia Martin (IEc) and moderated by Dale Engstrom (Oregon). The following Hanford Trustees and Technical Working Group members attended the panel:

- Dana Ward (DOE)
- Steve Wisness (DOE)
- Alex Nazarali (CTUIR)
- Jean Hays (Ecology)
- John Sands (DOE)
- Larry Goldstein (Ecology)

- Wade Riggsbee (Yakama Nation)
- Eric Buber (Ridolfi)
- Colin Wagoner (Ridolfi)
- Rico Cruz (CTUIR)
- Sandra Lilligren (ERWM, Nez Perce)
- Dib Goswami (Ecology)
- Ted Repasky (CTUIR)
- Matt Johnson (CTUIR) (by phone)
- Charlene Andrade (NOAA) (by phone)
- Daniel Diedrich (NOAA) (by phone)
- Sherry Duncan (Ridolfi) (by phone)
- Natalie Swan (Yakama Nation) (by phone)
- Jack Bell (Nez Perce) (by phone)

SECTION 2 DISCUSSION

INTRODUCTORY REMARKS

After introductions, Dale Engstrom began the panel with some introductory remarks on the purpose of the panel and agenda for the day (Appendix A), including the following.

- Main purpose and charge of the panel is to determine methods and technologies available to assess upwellings including the spatial and temporal variability of contaminant upwellings, and how to characterize the interactions at the bottom of the river. Some methods for discussion at the panel include geophysics, acoustic Doppler methods which detect velocity of movement, radon analysis, and sediment/water/biota sampling.
- In addition, the panel will hopefully determine the appropriate design of a sampling program to characterize contaminant upwellings or surrogate sampling plans for biota.
- The Trustees want to determine injury at the bottom of the river and the goal is to characterize and eventually quantify the impact of upwelling contaminants into the river.

SUMMARY OF 2008 HANFORD UPWELLINGS PANEL

Dr. William Woessner was one of the panelists in attendance at the 2008 Hanford Upwellings Panel (organized by Geomatrix), and he provided a brief summary of that earlier panel's recommendations (Appendix C). Dr. Woessner's main points are listed below.

- Significant work to characterize contaminant upwellings at Hanford has been completed, including work that was discussed at the 2008 panel. The current panel will build on that information.
- The goals for the 2008 panel included: 1) identifying likely mechanisms that control location, timing, and quantity of contaminated groundwater interfacing with the river (focus on 100-D area), and 2) identify critical information regarding groundwater- surface water exchange needed to design and implement effective remediation.
- The main recommendation from the 2008 panelists was to take a regional approach, and to think in 3D terms including groundwater sources, directions, discharge locations, and rates (i.e., investigate regional hydrologic context, and take local investigations to the complex complete river channel - including time and space complications, and develop a 3D conceptual model including determining the location of the groundwater divide).
- Data gaps the panelists identified include:
    - Map extent of contaminant plumes underneath the river;
    - Continue mapping preferential discharge locations at river bank;
    - Estimate hydraulic conductivity of the river bed and map associated sediment and rock types;
    - Map Ringold Mud occurrence under the river and consider as possible source term;
    - Assess importance of scour zones;
    - Characterize vertical distribution of contaminants in unconsolidated materials;
    - Characterize flow system on the other side of the river and its control on contaminant distribution in the river bed; and,
    - Estimate transport parameters.

In response to a question regarding the extent to which data gaps have been filled since the 2008 panel, John Sands described the work associated with the River Corridor Report and Interim Records of Decision as well as the Remedial Investigations, and how this work has contributed to filling some of the identified data gaps: additional wells have been drilled into Ringold Mud, transects have been sampled along the river, qualitative mapping of upwellings has occurred, and bathymetry data has been made readily available in GIS format. Dib Goswami added that they have determined that the Ringold Mud is not acting as a typical aquitard, and they have found contamination in the Mud unit itself; although the analysis is not complete yet.

PRESENTATIONS

After the summary of the 2008 panel, the discussion on additional work that has been completed on the river bed since 2008 began, and Dale Engstrom introduced Brett Tiller as the next presenter on his work with upwellings in the Hanford Reach.

Brett Tiller

Mr. Tiller presented his pore water sampling work using the Trident probe to investigate groundwater upwellings in the Hanford Reach as part of the Hanford Site Releases to the Columbia River Remedial Investigation from 2008 to 2010 (Appendix D). The main points from Brett's presentation are below.

- Brett's upwelling work was related to the Hanford Site Releases to the Columbia River Remedial Investigations from 2008 to 2010. He worked on identifying upwellings, screening for contaminated upwellings, making site selections for upwelling contaminant characterization, and comparing upwelling data for impacts from river fluctuation observations.
- The lack of data on the river bed had been identified as an important data gap. Brett and others began pore-water sampling work with the original Trident Probe, which had to be "toughened up" for the Columbia River – this technology provides a way to capture in-situ measurements and collection of pore water and surface water, as well as use in off-shore, turbulent water and rocky river beds.
- Adaptations to the probe include: "ruggedization", screened probe tip, hydraulic hammer to push the tip into the gravels, driving frame and rudder system, underwater camera system, and river stage monitoring checkpoints.
- Groundwater upwellings were found in all eight study regions; temperature and conductivity anomalies identified relatively high groundwater discharge areas; second and third Phase sample programs sampled the Phase 1 sites with the highest conductivity; high river stage was found to suppress pore-water conductivity. Conductivity values over 168 μS/cm indicated the presence of groundwater.
- Screened sub-set of areas to help choose areas for sampling (which takes longer than screening); avoided salmon spawning areas.
- It is difficult to determine the groundwater divide – Brett could not lump or split the data as near-shore versus far-shore to determine which side the groundwater is coming from. (Dr. Johnson suggested using a natural tracer such as a cation/anion analysis to distinguish water from each side.)
- The river stage played an important role in upwelling – data could differ daily and monthly due to the differences in river stage. Their approach to reducing the effects of river fluctuations included evaluating signals at QC stations such as groundwater signals, defining stable high-groundwater, response time of groundwater upwelling, and monitoring pore-water. Results included:
    - Avoid sampling when river levels are at or above 1 m above water mark for at least 1-2 hours prior to sampling.
    - Optimally, river levels should be less than approximately 0.8 m above the low water level for at least one hour.

- Intermittently perform pore water conductivity checks at selected QC sample locations near work site to check for signs of significant dilution from bank recharge and/or surface water pressure.
- Pore water conductivity readings should be greater than 90% of the conductivity measurements taken during prior sampling events when low and stead flows existed.
- Monitor river level before and after each sampling event.

- Sites exhibiting relatively high upwelling discharge rates were affected by surface water measurements one foot above the river bed.
- The presence of hexavalent chromium in pore-water at locations with corresponding hexavalent chromium concentrations in bulk sediment samples has implications for possible sediment transport.
- Brett's studies confirmed contaminated groundwater upwelling in off-shore and deep-water regions of the Columbia River and identified several locations where contaminant levels exceeded water quality standards.

The following are a list of questions/answers from Mr. Tiller's presentation.

- **There is huge variability in near shore environment, given the river conditions; to what extent can we use the Trident Probe and other methods to quantify adverse effects on biota?** One potential method is to use exceedance curves as a tool to make the link to biota injury.
- **Most data represent a snap shot in time; is there a way to continuously monitor data?** Yes, there is a way to continuously monitor data using the semi-permanent Trident Probe sampling device.
- **Sampling avoided salmon redds, but could you sample in redd areas once fry emerge to capture potential impacts in sensitive areas with redds?** The data has suggested that Chinook avoided upwellings, maybe because of dissolved oxygen levels. However, there are major spawning areas in the 100-H area that could be sampled, and sampling has taken place in known redd areas that were inactive. In addition, the active redds could be mapped, and the device set in place to sample once the salmon have left the area. Dale mentioned that he has heard that salmon might like areas of upwelling because of the high availability of nutrients.
- **Could a model be developed to estimate injury backwards into the past using available data?** This depends on how repetitive the groundwater data was at river stages (i.e., how consistent) because flow data are available back to 1960 which could be used to make predictions.
- **Could the semi-permanent probe be adapted to get samples in an easier way?** Yes, a tube could be attached to the probe and weights attached to major points along the bottom of the river until it reached the shore, and then it could be set to sample periodically. Bob Peterson mentioned that Hanford is already taking aquifer tube samples over time with an autosampler at the 300 Area.

Robert Peterson

Dr. Peterson gave a presentation on the context of groundwater and the hyporheic zone of the Hanford Reach (Appendix E). The main points from Dr. Peterson's presentation are below.

- To date, Hanford Site managers have relied on characterization of the flow and transport system to provide information for risk assessments, evaluating remedial action alternatives, and subsequent environmental restoration decisions. However, this panel is charged with discussing the opportunities and best path forward for estimating natural resource injury.
- However, the flow models make certain assumptions, such as assuming a consistent gravel type (bottom substrate).
- Data on the presence of redds, cross sections of the river system and groundwater domain, and hydrographs exist to help characterize areas of upwelling.
- Plume shapes and location vary seasonally. During low river stages, such as in December, the plumes move towards the river and the higher contaminant concentrations are near shore.
- Dr. Peterson presented a graph of the 300 area with data on aquifer tube locations, near-river well samples, maximum channel depth line, and monitoring well locations and concentrations. Bringing this data together on one diagram is complex, but allows for interpretation of all of the data together. These diagrams are available for all of the major contaminant areas on Site.
- A histogram showed the higher concentrations of uranium in water near the shoreline in the 300-Area; clam data showed a similar pattern.
- In summary, groundwater flow and contaminant transport processes are an integral part of characterizing the hyporheic zone. Ecological risk assessments can be focused on those areas of riverbed most likely to be impacted by the discharge of contaminated groundwater. Ample opportunity exists for research on the processes associated with the discharge of groundwater to streams and rivers.

The following are a list of questions/answers from Dr. Peterson's presentation.

- **Could historical spawning data help to understand the system?** The only shortcoming with the data on redds is that the data taken in the 1940s to 80s was snapshot data, and only in the 90s did they take aerial photos of redds. Data on yearly variation is not available.
- **How does the volume of discharge affect contaminant concentrations?** There is a low volume of discharge from Hanford to the Columbia River, which has a seasonal range of 40,000 to 250,000 ft^3/s. Hence, contaminants are highly diluted. Small amounts of U-236 have been found downstream as far as Astoria, Oregon, but the amounts are miniscule.

DISCUSSION OF CHARGE QUESTIONS

The charge provided to the panelists is attached as Appendix B. The discussion focused on 1) methods for approaching the problem of characterizing upwellings in the Hanford

Reach as a phenomenon as well as the spatial/temporal variability; 2) potential sampling designs; and, 3) evaluating broad sampling and efficacy of alternate strategies such as sampling biota.

Evaluate approaches for identifying river bed areas with likely occurrence of upwelling; and subsequently for characterizing the spatial and temporal nature of groundwater upwelling in those areas of the Columbia River channel, focusing on areas with known occurrence of upwelling. Potentaial approaches might include, but are not limited to, fiber optic grids, acoustic doppler profiler analysis, and geophysical surveys.

Dr. Woessner

- Dr. Woessner began the discussion by stating that there are many variables, but that what is needed is something to hinge the location of the upwellings to, and that he keeps returning to the concept that river bed geology is the key. Sampling is important, but needs to be hinged to the geomorphology (for example riffles, pools, low spots, redds, etc.).
- He also mentioned that it could be useful to identify areas that are not affected by contaminated upwellings, and therefore eliminate some of the river bottom that needs to be assessed. A "water divide" line could be drawn where uncontaminated water that comes in from the non-Hanford side of the River meets the Hanford side water. Once the area needing assessment is narrowed down, the next step would be to determine how to extrapolate data across the contaminated areas.
- Separating the impact of the river stage would also be valuable. If the river stage could be lowered by Grant County Public Power (the Priest Rapids Dam operator) for a limited investigation of upwelling impact, the impact of river stage on altered upwelling flow could be quantified.
- Dr. Woessner also stated that it might be possible to run small "box" simulations for different scenarios to see what happens under varying conditions, but would need to tie the simulation to observational data such as hydraulic head data.
- Dr. Peterson agreed that simulation may be ideal, but it is very expensive and determining data quality objectives ahead of time is very important.

Dr. Johnson

- Dr. Johnson agreed with Dr. Woessner's suggestion to narrow the assessment area.
- He also mentioned that there is a lot of sediment and groundwater path heterogeneity in the areas with documented upwellings, so it is difficult to determine spatial variability.
- He favors using semi-permanent tips on the Trident Probe (mentioned previously during the discussion of Brett Tiller's presentation). This method could be particularly useful if sampling (of water and sediment) could be incorporated into the design of the semi-permanent probe to accompany the data on conductivity (since specific conductance alone does not identify groundwater contamination).

- Porous ceramic passive sample cups might work providing an integrated measurement which would also help identify potential injury to biota.

Dr. Peterson

- Dr. Peterson stated that there is an abundance of data at Hanford (including hydrodynamic flow modeling, credible water table data, recent bathymetric data, LIDAR river bottom data, geophysics, fiber-optic cable temperature data, towed camera video information and Trident probe data), and if interpreted differently than the RI/FS did, could help to narrow the scope.
- He mentioned that it might also be helpful to characterize the opposite bank of the river to determine if the opposing groundwater masses could be characterized by geochemical differences. This would allow determination of the groundwater divide and elimination of river bed areas between reactors that are likely not contaminated.
- Groundwater flow geochemistry studies can be very useful to eliminate areas of the river bed between reactors that are not contaminated, but also very expensive. However, once a conceptual model is established, it could be extrapolated over the rest of the river bottom. It is important to have water data from wells to correlate with the model, but that data are unavailable for the opposite bank.
- Although a hydrologic model could be useful, Dr. Peterson still believed observational data are the best. For instance, a video camera towed along the bottom of the river could help characterize the geology of the bed.
- Another potential option is geophysical surveys or fiber optic temperature surveys, which is also reasonably priced. Ted Repasky agreed that geophysics is a powerful way to identify conductivity differences along the river bed.
- Dr. Peterson reminded the Panel that the difficulty is that the River faces a number of stressors, including non-Hanford stressors, and it is important to agree on how to deal with this issue as well as whether you are concerned with current or past conditions.
- Identifying areas that are not injured can help to limit the investigation and budget. A simple box model on either side of the river could be set up as a small scale conceptual upwelling model, with river bottom topographic effects simulations to match known scenarios. It could be used to define groundwater and river stage parameters. It would require chemical and head data to populate the model, and it would take three to four blocks to extrapolate to the rest of the river (such as the 100-H, 100-K, and 300 area).

Evaluate methods for sampling to quantify contaminant chemistry in areas of upwelling. The modified Trident probe is viewed as the default sampling device, but panelists are requested to identify and suggest alternate methods.

- The semi-permanent Trident probe system has the capability of collecting conductivity, temperature, and sediment and water sampling data. This way, contaminant chemistry data could be correlated with conductivity.

- Dr. Woessner posed the question of what could be learned if the Trident Probe collected deeper samples. (Trident probe can collect samples as deep as four feet.) He anticipated higher concentrations as the probe goes deeper, but it may provide information on what is happening below and about the physical flow of the system by determining the path the groundwater took to reach the area.

Evaluate potential sampling design to characterize the spatial and temporal variability of water chemistry (major ions and contaminants) in areas of upwelling.

A summary of the thoughts on sampling design included utilizing a geo-statistical sampling grid to determine the density of the upwelling sites. Once the size of the area of each upwelling is known, it could drive the size of the sampling grid cells. Understanding the scale of upwelling and of impacted areas is very important to sampling design, as well as the heterogeneity of the river bottom sediment distribution and how that related to the upwelling sites. An understanding of scale could also help determine the major uncertainties.

Mr. Tiller

- Mr. Tiller stated the importance of identifying places of ongoing remediation when designing a study. Areas with remediation are not going to be predictive of areas without remediation.
- Sandra Lilligren asked Mr. Tiller how he would do things if he had unlimited funding. Mr. Tiller said there are other studies he would do with more funding. He would expand on the semi-permanent tip sites he has developed, with tubing coming to the shore so that he could easily obtain water samples from these sites. Mr. Tiller ran one semi-permanent system for 3 to 4 days until the battery ran out, but it would be possible to run the system longer (e.g., months to years) with a shore-mounted, solar battery unit as long as the cables/tubing line was placed in a location without much debris. The mesh size of the screen could also be changed to prolong the life of the unit.
- Dr. Peterson added that the probe could sample deeper than one foot to avoid debris, and Mr. Tiller said it could sample as deep as four feet. Dr. Woessner added that the system could be programmed to take samples at certain river stages only to ensure groundwater samples were obtained.
- In terms of sample size, it is important to determine what groundwater map pixel resolution is desired.

Dr. Johnson

- Dr. Gary Johnson believed it would be much easier to design a worthwhile study once the target (biota) are determined – it is better to ask the question of what the data will be used for before designing a study to ensure the appropriate data are obtained.
- Ideally, the Trustees could set up a geo-statistical sampling program to determine the trend and extrapolate to the larger scale, but it may be difficult to do in the

Columbia River system. And the most important data will be those describing contaminant information.

Dr. Woessner

- Dr. Woessner argued that a study would not need to cover the whole area of the river, but just areas that are contaminated. It might help to determine the extent of contamination around operable units (i.e., how far contamination spreads from the operable unit area).
- The dam operations influence the whole system, so it will be difficult to separate those influences from Hanford effects. Charlene Andrade mentioned that the Hanford Aquatic Technical Working Group has been working to understand the dam influences and examining hydrographs to help weed out uncertain areas and find injury associated with contamination and not by altered flows. Dr. Peterson mentioned that the recent bathymetry data are available and took advantage of Lidar data.

Dr. Peterson

- After Dale Enstrom asked the specific question of what is the number of key areas of study necessary to obtain sufficient information, Dr. Peterson said that his ideal study areas would be at the 300 Area uranium plume, the chromium plume at 100-D area, and the chromium plume at 100-H area. Dr. Peterson did not think K area would be particularly helpful because it is smaller and is farther away from spawning areas.
- Determining where there is *no* injury can be just as important and useful as determining where injury exists.
- Dr. Peterson also mentioned the issue of cultural sites in relation to determining sampling locations. Wade Riggsbee stated that folks have been working with the tribes on this issue.

Evaluate approaches and methods for broad spatial sampling to map the locations of contaminant upwellings at reactor areas in the Hanford Reach. Panelists are encouraged to consider the efficacy of alternate sampling strategies, such as sampling of substrate or sessile biota (e.g., periphyton, clams, and/or invertebrates) as a less costly surrogate for direct sampling of water using a device such as the Trident probe.

Mr. Tiller

- Mr. Tiller described his work in the 1990's related to sampling aquatic biota. He sampled Asiatic clams and determined a useful sampling utility. At low river stage, the clams had time to accumulate contaminants but the turn-over rates for clams to flush out the contaminants was very short, 48 to 72 hours.
- However, there is some utility in studying hard shells also. Mr. Tiller tried power grabs, but these were not very effective in areas where there were rocks.

- He developed Trident-based split-spoon sampling tube methods instead which helped obtain sediment and biota samples.
- Dale asked if he found any association between contaminated water and sediment, and Mr. Tiller said yes, there was an association.
- Mr. Tiller's fish sampling program was primarily focused on human health (i.e., fish consumption), and he did find some contamination.
- Many of the fish species sampled had large home ranges, so the testing provided a good indicator for these types of species but not for more localized species such as the sculpin.
- However, he did some sculpin testing and found uranium, chromium in fillets, and strontium-90 contamination in bones, as well as tritium in some fish tissues and hexavalent chromium in sturgeon tissues.
- John Sands added that the most important fish-related drivers for human health in the Columbia River Component risk assessment were mercury and PCBs, and that there was not much found of the Hanford-specific constituents.

Dr. Peterson

- Dr. Peterson had the opportunity to collect 'slime' (algae and fine minerals which absorb heavy metals and radionuclides); he peeled and scraped it off reactor areas and analyzed for metals. He found mining metals from upstream, but also found chromium from Hanford groundwater. This type of analysis could provide useful information for a low cost.
- Mr. Tiller warned that it is important to be aware of sediment size, to ensure the results are not influenced by sediment size (i.e., more contamination because of finer sediment).

Dr. Woessner asked about the use of microinvertebrates

- Mr. Tiller discussed his work for RCBRA; he set out colonization baskets and the results had hits of contamination.
- The band of periphyton changes composition with depth; two meters below the low water mark turns to cobble and there are not many periphytes.
- Mr. Tiller has not set out rock baskets in deeper areas, but this is also an option.
- Sampling periphyton is extremely hard, because it is difficult to gather enough volume of sample material for each sample.
- Mr. Tiller was not sure if there were macro-invertebrates in the groundwater; it is not expected in the Hanford area due to lack of permeability but macro-invertebrates could be present in Hanford gravels.
- Dale mentioned his thesis work, in which stoneflies would crawl out of wells after they moved through the groundwater from the river; it was a normal part of their lifecycle. Ted Repasky added that stoneflies are present in the groundwater wells around the Yakima River.

- Dr. Woessner mentioned that they may not be seen around Hanford because of the screen size of the well; they might be an important part of the food web.

Measuring contaminant concentrations is important in determining and quantifying potential injury to aquatic biota; consider how pore water chemistry changes with depth in substrate, and methods to capture those changes.

- This question was answered during the discussion of previous questions described above.

CLOSING REMARKS

Dale Engstrom summarized the panel discussions at the end of the panel. His main points are listed below.

- When designing a study to characterize areas of upwelling, it is important to determine areas that we do not need to study (inexpensive cation-anion analysis might help to narrow sites down by helped to distinguish areas affected by groundwater from the Hanford side versus areas only affected by groundwater from the non-Hanford side).
- Geophysics could be an important tool to distinguish one area of the river from another (such as in the Slater et al. 2010 article).
- It is possible to pick a site, such as the 100-H area, to characterize impacted areas, and then extrapolate outwards to determine upwelling potential.
- Temperature sensing devices (like the fiber optic cables) could also be used.
- There is also value in ground truthing and field checking any models that are created.
- Dr. Woessner and others mentioned the importance of a sampling program that is hinged on something concrete such as the geomorphology of the river.
- Further investigation on temporal variability using the semi-permanent sampling probe could be very useful.
- However, we still need a solution for how to investigate how plumes move in the river bed and what pathways control their flow.
- In areas of known occurrence and large flows, simulation may be used to characterize the upwelling (influencing variables to gain insight into the main drivers of the system). Using these simulations will produce insights into which parameters are controlling influences on what is being seen.
- Screening assessment areas ahead of time can also help to determine the most effective areas for study, particularly if using the semi-permanent probe for study.
- Areas of outfalls, which seem to be better at sampling groundwater, may also provide insight into what is happening in the river.

In conclusion, the panelists stressed the importance of focusing on the goal of a study and considering what kind of data will be required and what will be done with the data before designing an upwelling study plan. Therefore, the group concluded that a subsequent meeting, preferably with the Hanford Aquatic Technical Working Group members, to discuss the panelists' recommendations would be important to identify the sampling data needed to not only characterize areas of upwelling but also to establish potential injury to aquatic biota.

Hanford Natural Resource Damage Assessment Expert Panel:

Characterizing the Nature and Extent of Contaminant Upwellings in the Hanford Reach of the Columbia River

AGENDA

May 4, 2012

9:00 – 9:15	Introductions (including short description of any previous work at Hanford Site or any possible conflicts of interest)
9:15 – 9:45	Summary of 2008 Hanford expert panel on upwellings (Dr. Woessner)
9:45 – 10:00	-- Break –
10:00 – 11:00	Presentations on Previous Hanford work and Experiences (Robert Peterson and Brett Tiller)
11:00 – 12:30	Discussion of charge questions (each panelist will have approximately 10 minutes per question
12:30 – 1:45	-- Lunch (on your own) –
1:45 – 3:00	Continuation of charge questions (each panelist will have approximately 10 minutes per question)
3:00 – 3:45	Conclusions and summary remarks from each panelist
3:45 – 4:00	Wrap-up and Closings

APPENDIX B PANEL CHARGE

HANFORD NRDA EXPERT PANEL | May 4, 2012

CHARACTERIZING THE NATURE AND EXTENT OF CONTAMINANT UPWELLINGS IN THE COLUMBIA RIVER FOR PURPOSES OF NATURAL RESOURCE INJURY ASSESSMENT

This memorandum provides a general description of the purpose, need, scope, and charge for the Hanford Expert Panel on characterizing the nature and extent of contaminant upwellings in the Columbia River as part of the Hanford Natural Resource Damage Assessment (NRDA).

INTRODUCTION

The Hanford Site, operated by the U.S. Department of Energy (DOE), is located on approximately 586 square miles of land bordering the Columbia River in southeastern Washington. Construction of nine reactors and associated uranium processing facilities began in 1943; subsets of these reactors and other production facilities were in operation from 1944 to 1987. At this time the primary mission of the Hanford site is environmental cleanup. The production processes generated billions of gallons of liquid waste and millions of tons of solid waste (DOE 2012). The DOE, Washington State Department of Ecology, and U.S. Environmental Protection Agency (EPA), signed the Hanford Facility Agreement and Consent Order (Tri-Party Agreement) in May 1989, which outlines legally enforceable milestones for Hanford cleanup over the next several decades. In November 1989, EPA placed the Hanford Site on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL).

When the release of one or more hazardous substances is suspected to have led to "injury" of natural resources, Federal law allows government officials, acting as natural resource "trustees", to enter into a Natural Resource Damage Assessment (NRDA) process. The objective of the NRDA process is to restore, replace or acquire the equivalent of injured natural resources and to compensate the public for any loss of services that occurs while natural resources are in an injured state. The Hanford Natural Resource Trustee Council (HNRTC) is a collaborative working group chartered to address injuries to natural resources resulting from contaminant releases from the Hanford Site. The Council is made up of representatives from the Department of Energy, the U.S. Fish and Wildlife Service, the National Oceanic Atmospheric Administration, the state of Oregon, the State of Washington, the Yakama Nation, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation.

As part of the NRDA, the HNRTC is preparing an Injury Assessment Plan (IAP). The IAP will describe injury assessment activities that will inform the HNRTC's evaluation of the extent to which natural resources and associated services in and around the Hanford Site have been affected by the release of contaminants. To help with the development of the IAP, the Trustees are conducting a series of expert panel workshops to explore various issues related to the assessment of injury at the Hanford Site. The purpose of these workshops is to provide expert advice to the Trustees, opportunity for the exchange of ideas and information, and to inform the IAP by helping the trustees develop the best path forward and prioritize potential future injury studies (i.e., studies to characterize injury to natural resources from the release of contaminants).

Additional information on the Hanford Site can be found at www.hanford.gov, and information on the Hanford NRDA process and the HNRTC can be found at www.hanfordnrda.org. The NRDA regulations are found in Title 43 of the Code of Federal Regulations, Part 11. For reference, some key definitions of NRDA terminology are listed below, and all other key definitions can be found in 43 C.F.R. § 11.14.

Injury means a measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a discharge of oil or release of a hazardous substance, or exposure to a product of reactions resulting from the discharge of oil or release of a hazardous substance. As used in this part, injury encompasses the phrases "injury," "destruction," and "loss." Injury definitions applicable to specific resources are provided in §11.62 of this part.

Natural Resources or *resources* means land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson Fishery Conservation and Management Act of 1976), any State or local government, any foreign government, any Indian tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian tribe. These natural resources have been categorized into the following five groups: Surface water resources, ground water resources, air resources, geologic resources, and biological resources.

Biological resources means those natural resources referred to in section 101(16) of CERCLA as fish and wildlife and other biota. Fish and wildlife include marine and freshwater aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and State sensitive species. Other biota encompass shellfish, terrestrial and aquatic plants, and other living organisms not otherwise listed in this definition.

Services means the physical and biological functions performed by the resource including the human uses of those functions. These services are the result of the physical, chemical, or biological quality of the resource.

PURPOSE AND NEED

In 2008, an expert panel was convened at Hanford to "provide observations and suggestions intended to improve the current understanding of groundwater-surface water interactions in the 100 Areas, and to identify what additional analyses or approaches may provide critical information . . . that will minimize impacts to river aquatic systems." The panel focused on the 100-D Area at Hanford, and on the fate of hexavalent chromium. At the time the panel met, techniques for characterization of waters upwelling into the bed of the Columbia River had not yet been successfully developed or implemented in the challenging environment of the Columbia River (i.e., deep, fast-flowing water, variable water levels, hard, often rocky substrate). The panel recommended a variety of field sampling and modeling efforts to better understand the fate and transport of chromium. Recognizing the highly heterogeneous nature of the geologic setting and the transient nature of groundwater flow, the panel noted that "snap shots" of contaminant measurement make it difficult to interpret data. Among its recommendations, the panel noted that "The design and installation of remote retrievable samplers and/or sensors that could be installed at a few selected locations to examine the transient nature of exposure of biota to the contaminants of concern may be beneficial . . ."

Since the panel issued its report, advances in technology, such as the refinement and successful deployment of the modified Trident probe in the Hanford Reach, have enabled sampling of water and contaminants in the hyporheos. This sampling has demonstrated widespread occurrence of groundwater upwelling in the bottom of the Columbia River, identified by anomalies in water temperature and/or specific conductance. In addition, water sampling and analyses have demonstrated upwelling of contaminants including hexavalent chromium, uranium, tritium, technetium-99, and strontium-90. Because sampling is slow, the current extent of river bottom sampling – in space and time - has been insufficient to characterize the spatial or temporal variability of contaminant upwelling, and thus insufficient to assess exposure and potential injury to aquatic biota in the Columbia River. To address this data gap, Hanford Natural Resource Trustees are proposing additional study to characterize the spatial variability of upwelling areas in the Hanford Reach, and to assess the transient nature of contaminant concentrations. This is tentatively envisioned as a two-stage study – first a focused effort, looking at a few known areas of contaminant upwelling, to better understand temporal and small-scale spatial variability of contaminant upwelling, to be followed by a broader effort to survey or "map" contaminants in large areas of the Hanford reach.

The purpose of this expert panel is to provide guidance to the HNRTC by evaluating options for the design of a project to address the contaminant upwelling data gaps. The goal for the panel is to develop recommendations to the trustees for studies to better assess the nature of upwellings in the Hanford Reach, focusing on characterizing upwellings as well as the concentrations of contaminants to assist in determining and quantifying potential injury to aquatic biota in the river. The panel/workshop format is intended to foster an open exchange of ideas and information among individuals involved in site-specific work at Hanford with peers with a broader perspective on groundwater hydrology and contaminant fate and transport.

PANEL MANAGEMENT

INFORMATION AND PREPARATION REQUIREMENTS

In preparation, members of the expert panel are expected to review information on contaminant upwellings in the Columbia River. Panelists are also requested to specifically review the following documents and materials as needed based on prior knowledge of the subject and/or the Hanford Site:

Site-specific documents

- The *Groundwater Natural Resource Review Report* and the *Aquatic Natural Resource Review Report* (Industrial Economics, Inc., Nov. 2011).
- Project 23 Study Proposal: Characterization of Upwelling in the Hanford Reach of the Columbia River, February 7, 2012 – This is a preliminary draft study plan for the HNRTC, however funding has not been committed for the study. The study design is tentative and will likely be modified based on panel recommendations.
- SGW-39305. *Technical Evaluation of the Interaction of Groundwater with the Columbia River at the Department of Energy Hanford Site, 100-D Area.* Fluor Corporation, Richland, WA. October 2008 (report of 2008 Hanford expert panel).
- Pertinent Sections of WCH-380 *Field Summary Report for Remedial Investigation of Hanford Site Releases to the Columbia River, Hanford Site, Washington.* Washington Closure Hanford, Richland, WA, November 2010 (including Appendices A, G, H, J, K).
- Pertinent Sections of WCH-398 *Data Summary Report for the Remedial Investigation of Hanford Site Releases to the Columbia River, Hanford Site, Washington.* Washington Closure Hanford, Richland, WA, January, 2011.
- PNNL-17836 *Methods for Assessing the Relative Amounts of Groundwater Discharge into the Columbia River and Measurements of Columbia River Gradients at the Hanford Site's 300 Area.* Pacific Northwest National Laboratory, September 2008.
- PNNL-16805 I*nvestigation of the Hyporheic Zone at the 300 Area, Hanford Site.* Pacific Northwest National Laboratory, October 2007.

Field Techniques

- LaBaugh, JW, and D.O. Rosenberry. 2008. *Field techniques for estimating water fluxes between surface water and ground water*: U.S. Geological Survey Techniques and Methods 4–D2, 128 p.
- Oberg, KA, Morlock, SE, and Caldwell, WS. 2005. *Quality-assurance plan for discharge measurements using acoustic Doppler current profilers*: U.S. Geological Survey Scientific Investigations Report 2005-5183, 44 p.
- Lerch, JA, Tiller, BL, Paulsen, R. 2009. *Use of the Advanced Trident Probe to Investigate Upwelling Groundwater in the Columbia River Hanford Reach –* 10558. WM2010 Conference, Phoenix, Arizona.
- PNNL-17270 *Evaluation of Using Caged Clams to Monitor Contaminated Groundwater Exposure in the Near-Shore Environment of the Hanford Site 300 Area.* Pacific Northwest National Laboratory, January 2008.
- Slater et al. 2010. *Use of electrical imaging and distributed temperature sensing methods to characterize surface water - groundwater exchange regulating*

uranium transport at the Hanford 300 Area. Water Resources Research, vol 46, W10533.

We anticipate that panelists will require approximately one day of pre-panel preparatory work, depending on familiarity with the Site and documents in question. Upon request of the panelists, IEc can provide access to the documents cited in reports we have developed.

Panelists should come prepared to address the following charge questions:

- Evaluate approaches for identifying river bed areas with likely occurrence of upwelling; and subsequently for characterizing the spatial and temporal nature of groundwater upwelling in those areas of the Columbia River channel, focusing on areas with known occurrence of contaminant upwelling. Potential approaches might include, but are not limited to, fiber optic grids, acoustic doppler profiler analysis, and geophysical surveys.
- Evaluate methods for sampling to quantify contaminant chemistry in areas of upwelling. The modified Trident probe is viewed as the default sampling device, but panelists are requested to identify and suggest alternate methods.
- Evaluate potential sampling design to characterize the spatial and temporal variability of water chemistry (major ions and contaminants) in areas of upwelling. Panelists are asked to consider and make recommendations in terms of factors such as:
    - Number of areas to be sampled;
    - Density and numbers of samples within each area;
    - Depth of sampling at the water/sediment interface and at depth in sediments; and,
    - Duration/timing of sampling to characterize presumptive changes in volume and chemistry of upwelling water associated with diurnal and seasonal changes in river level.
- Evaluate approaches and methods for broad spatial sampling to map the locations of contaminant upwelling at reactor areas in the Hanford Reach. Panelists are encouraged to consider the efficacy of alternate sampling strategies, such as sampling of substrate or sessile biota (e.g., periphyton, clams, and/or invertebrates) as a less costly surrogate for direct sampling of water using a device such as the Trident probe.
- Measuring contaminant concentrations is important in determining and quantifying potential injury to aquatic biota; consider how pore water chemistry changes with depth in substrate, and methods to capture those changes.

Panelists are asked to provide recommendations to the HNRTC regarding how to effectively and efficiently assess the nature of contaminant upwellings in the Columbia River. The HNRTC specifically asks for recommendations for studies and analyses that could be conducted to characterize the spatial variability of selected upwelling areas and to assess the transient nature of contaminant concentrations in the Columbia River, as well as for studies to define the spatial extent of upwelling. Emphasis should be placed on characterizations that will assist in determining and quantifying injury to aquatic biota in the River environment.

APPENDIX C — DR. WOESSNER: GROUNDWATER SURFACE WATER INTERACTIONS WORKSHOP 2008
(Posted on Hanford SharePoint Site)

APPENDIX D — MR. TILLER: USE OF THE LIQUID TIP TRIDENT PROBE TO INVESTIGATE GROUNDWATER UPWELLING IN THE COLUMBIA RIVER HANFORD REACH: A REVIEW OF RECENT SAMPLING EFFORTS
(Posted on Hanford SharePoint Site)

APPENDIX E — DR. PETERSON: GROUNDWATER AND THE HYPORHEIC ZONE OF THE COLUMBIA RIVER, HANFORD SITE, WASHINGTON
(Posted on Hanford SharePoint Site)