POLLUTION CONTROL HEARINGS BOARD
FOR THE STATE OF WASHINGTON

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| AIRPORT COMMUNITIES COALITION,<br><br>Appellant,<br><br>v.<br><br>STATE OF WASHINGTON, DEPARTMENT OF ECOLOGY; and THE PORT OF SEATTLE,<br><br>Respondents. | No. 01-133<br>No. 01-160<br><br>DECLARATION OF DR. PATRICK LUCIA IN SUPPORT OF ACC'S MOTION FOR STAY<br><br>(Section 401 Certification No. 1996-4-02325 and CZMA concurrency statement, issued August 10, 2001, Reissued September 21, 2001, under No. 1996-4-02325 (Amended-1)) |

Dr. Patrick Lucia declares as follows:

1. I am over the age of 18, am competent to testify, and have personal knowledge of the facts stated herein.

2. I am a Civil and Environmental engineer having received my Ph.D. in Civil Engineering. I have over 25 years experience in both consulting and in academia. I am a Principal with GeoSyntec Consultants. During the period of 1984 to 1986 I was a Visiting Lecturer in the Civil Engineering Department at the University of California at Berkeley, during 1990 to 1991 I was a Senior Lecturer at the University of California at Davis in the Civil Engineering Department. In 1989 I was an invited lecturer in a USEPA environmental technology transfer program in Korea and in 1995 was an invited lecturer at a NATO Advanced Study Institute on Groundwater pollution Control and Remediation in Turkey. I have also been a lecturer for the National Groundwater Association and the



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University of Wisconsin. My practice has broadly covered environmental and civil issues related to soils, groundwater and surface water. A copy of my curriculum vitae is attached as Exhibit A.

3. I have been in charge of previous reviews of geotechnical and seismic issues relating to the analysis and design of the embankment fill and MSE walls. I have been co-author on the following letters previously submitted to Ecology and the U.S. Army Corps of Engineers:

- GeoSyntec Consultants (2001), "Comments on Seattle Tacoma International Airport Project – Third Runway – Embankment Fill and West MSE Wall, and Industrial Wastewater System Lagoon #3 Expansion Project – On Second Public Notice," Letter to U.S. Army Corps of Engineers and Washington State Dept. of Ecology, 16 February 2001.
- GeoSyntec Consultants (2001), "Implications of Preliminary Findings from the Nisqually Earthquake of 28 February 2001 on the Seattle Tacoma International Airport - Third Runway – Embankment Fill and West MSE Wall Expansion Project," Letter to U.S. Army Corps of Engineers and Washington State Dept. of Ecology, 15 March 2001.
- GeoSyntec Consultants (2001), "Response to the Port of Seattle's comments on the GeoSyntec Consultants letter of 16 February 2001," Letter to U.S. Army Corps of Engineers and Washington State Dept. of Ecology, 22 June 2001.
- GeoSyntec Consultants (2001), "Comments on Recently Received Documents Pertaining to Seattle Tacoma International Airport Project – Third Runway – Embankment Fill and West MSE Wall," Letter to U.S. Army Corps of Engineers and Washington State Dept. of Ecology, 6 August 2001.



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4. I have reviewed the Port's and Ecology's declarations, exhibits and briefs submitted in opposition to ACC's motion for stay. Additional documents reviewed include, but are not limited to the following:

- Ellingson, C. (2001) "Modeled Area and Hydrus Model Results Draft Interim Deliverables," Memorandum to Keith Smith of the Port of Seattle from Charles Ellingson of Pacific Groundwater Group, June 25, 2001.
- Pacific Groundwater Group (2000) "Sea-Tac Runway Fill Hydrologic Studies Report," prepared for Washington State Department of Ecology, June 19, 2000.
- Pacific Groundwater Group (2001) "Port of Seattle Sea-Tac Third Runway Embankment Fill Modeling," prepared for port of Seattle, August 8, 2001.
- Parametrix, Inc. (2001) "Low Flow Analysis – Flow Impact Offset Facility Proposal," prepared for Port of Seattle, July 2001.
- U.S. Fish and Wildlife Service (FWS, 2001) *Biological Opinion*, May 22, 2001.
- Washington State Department of Ecology (2001) *Original 401 Certification*, August 10, 2001.
- Washington State Department of Ecology (2001) *Amended 401 Certification*, September 21, 2001.

**Introduction**

5. As already mentioned, I have previously been in charge of the review of numerous documents relating to the seismic and geotechnical analyses and design related to the construction of the embankment fill and MSE walls for the proposed Third Runway Expansion at the Seattle Tacoma



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International Airport. In those reviews, consistent gaps in the analysis methodologies and implementations were uncovered. The commentary that follows demonstrates that these types of gaps were also uncovered in a review of the Port's Low Flow Analysis. Additionally, several questions are raised regarding the fill screening criteria for the embankment, and the criteria were found to be inconsistent with the requirements set forth by the U.S. Fish and Wildlife Service (FWS). The key points that will be made can be summarized as follows:

- the implementations of Hydrus and Slice models are overly simplistic, with potentially serious impacts on the timing of flow through the embankment fill;
- there appears to be no analysis of the time that will pass between initial completion of the embankment and the emergence of the predicted level of water at the base of the fill. This initial lag, as the fill gets wetted and absorbs water for the first time, could be on the order of years, during which time low stream flows may not be sufficient;
- selection of model parameters to represent the hydraulic properties of the fill were based on very limited data that demonstrates a high degree of uncertainty. Model parameters should have been calibrated with laboratory tests;
- uncertainties in methodology and implementation of the low flow models demands performance of a sensitivity analysis to evaluate the potential range in results with variations in input. Without this analysis, it is impossible to tell whether the results are a valid representation of post-construction flow conditions;



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- the September 2001 401 Certification represents a reduction in the protection standard for fill screening versus the August 10, 2001 401 Certification;
- the 401 Certification does not meet all of the requirements of the FWS Biological Opinion;
- fill screening criteria are based on dispersion of contaminants as opposed to the creation of point sources where the collected water is delivered to the creek;
- The testing protocol for fill borrow sources in the September 2001, 401 Certification does not provide sufficient assurance that the environmental fill criteria will be met.

6. Review of these issues leads to a clear conclusion that there is insufficient evidence in the analyses to support the Port's mitigation plans.

**Review of Low Flow Analysis**

7. **Comment A:** The use of the two-dimensional Hydrus model to evaluate flow through the embankment in a one-dimensional sense is both an underutilization of the capabilities of the program, and more importantly, a potentially serious misrepresentation of the flow conditions in the field which most likely impacts the timing of flow reaching the creek below.

8. The Port's consultants have used Hydrus, a two-dimensional finite element program for modeling saturated and unsaturated flow and contaminant migration, to simulate the flow of water through the fill in a vertical direction only. In other words, water that enters the fill during a rainfall event is modeled as traveling straight down to the drainage layer below, rather than the much more realistic scenario of following a flow path that incorporates both vertical and horizontal movements.



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The program used for this analysis is fully capable of modeling flow in both the vertical and horizontal directions and would likely produce a more realistic outcome if used in that way.

9. Several scenarios are being ignored completely by performing this one-dimensional (purely vertical) analysis. First, the embankment fill will undoubtedly be very heterogeneous, with significant variation in soil properties. As such, there will be regions with low vertical hydraulic conductivity (i.e. the fill in certain areas will be more resistant to vertical flow of water) and higher horizontal hydraulic conductivity which will cause the advancing water to travel in a largely horizontal direction until it finds a more permeable material and travels downwards again. Second, water that is traveling near the face of the slope may in fact travel horizontally and emerge at the face of the slope as a seep, and then continue down the face of the slope as runoff. Finally, the scenario being modeled shows the fill underneath the runway and other impervious areas to be completely dry. In other words, if (1) the runway is impervious and blocks migration of water underlying the fill , and (2) all of the water is modeled as traveling vertically, then water will never wind up underneath the runway. In reality however, where water travels downwards through the fill, it will tend to migrate into the drier areas and will likely travel a long way, or even all of the way underneath the runway until it encounters the wet fill on the other side.All of these scenarios, and others that have not been described, would lead to a change in the time lag of the water traveling through the fill. As a result, given the highly variable nature of the fill properties, the amount of flow that reaches the creeks during the low flow months could be very different than predicted. The Hydrus program has the capability of modeling a more complex two-dimensional scenario and should have been used in that capacity.



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10. **Comment B:** The modeling does not provide a reasonable representation of the length of time it will take after completion of the embankments before the predicted flows will reach the stream. It may take several years before significant water emerges from the fill embankment and in that time the low flow conditions may be much more severe than predicted.

11. When the embankment fill is constructed, it will contain a specified amount of moisture. However, both during construction and in the first few years after construction, the embankment will likely not have reached its storage capacity. In other words, it will take some time before the fill has absorbed sufficient water that it will readily allow all of the water that infiltrates at the ground surface to run out into the drainage layer below and discharge to downgradient surface waters. Based on the modeling presented, there does not appear to be a good indication of how long it will take for the fill to reach capacity. Given the vast quantities of fill being considered for this project, it could take several years before the fill reaches capacity and in that time the actual low flow conditions in affected streams may be much worse than predicted.

12. **Comment C:** The use of the "Slice" model is a questionable tool, as is the decision to use disconnected models to evaluate flow over and through the embankment to the creeks below.

13. The "Slice" model used for evaluating flow below the embankment fill appears to be an in-house spreadsheet program. There does not appear to be any discussion in the reports that address the verification of the program (i.e. the ability of the model to correctly solve the governing flow equation). Moreover, it appears that artificial adjustments were implemented under certain conditions. In their report, PGG (2000) states (page E-5):



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"The mass balance, defined above in equation 1, is performed for every cell for every time-step of the model simulation. For each time-step, mass balance proceeds in consecutive order from upgradient to downgradient cells. In certain instances, when recharge and/or available storage are low, adjustments were required to the till outflow term for the groundwater flow system to ensure that predicted outflows did not exceed available inflow and storage. When such instances occurred, till seepage was scaled back so as not to exceed available volumes."

14. The governing equations for saturated groundwater flow represent a mathematical statement of mass balance (i.e. every drop of water is accounted for). An accurate numerical representation of these equations (e.g. a computer model) should therefore yield solutions that conform to this mass balance. As described by PGG, artificial adjustments were required in order to ensure that predicted outflows were not larger than inflows (i.e. to ensure that water was not created by the model). These artificial adjustments are not standard, should not be required, and suggest a potential problem with the numerical algorithm used. This issue further supports the need for verification of the spreadsheet model.

15. Anderson and Woessner (1991) specifically address the use of spreadsheet models, stating:

"...from an operational standpoint it is doubtful that spreadsheet solutions offer any advantages over standard computer codes. The equations one needs to enter into the spreadsheet become increasingly complex when sources, sinks, and transient conditions are represented. ... The time required to set up and test a complex spreadsheet model is likely to be equal to or greater than the time needed to set up and run a standard flow code. Moreover, the standard flow codes ... are versatile, readily available at nominal cost, contain options for computing boundary fluxes and other water balance terms, and are well tested and accepted by the modeling community."

16. Given this assessment together with the apparent lack of verification of the "Slice" model, a more appropriate program, and a more accepted program, for modeling these conditions is



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MODFLOW. This program is by far the industry standard for simulating saturated groundwater flow. It is well documented, widely tested and widely accepted in the groundwater modeling community.

17. Alternatively, a more complete approach would have been the application of Hydrus for modeling two-dimensional unsaturated flow (the embankment fill) as well as saturated groundwater flow (the drainage layer), thereby eliminating the "Slice" program altogether. Hydrus is fully capable of simulating saturated-unsaturated flow processes in two dimensions. In this manner, flow in the embankment fill and drainage layer would be fully integrated, and a more accurate representation of the soil conditions could be introduced. Additionally, use of a single program to model both of these flow regimes eliminates the step of transferring output and input data, removing a potential source of error.

18. **Comment D:** A formal sensitivity analysis should have been performed on the various parameters of the low flow model to examine the potential for small changes in uncertain model input values to have a large influence on the predicted stream flows. As a result of the numerous uncertainties, the current level of analysis is insufficient for an evaluation of the amount of water that needs to be retained to mitigate low flow impacts.

19. No sensitivity analysis was presented for the low flow analyses. This is particularly crucial given the numerous distinct parameters and steps involved in the analyses. The PGG (2000) report states (pg. 52):

> "A formal model sensitivity analysis was not conducted. However, the distribution of water quantity between surface/drain flow and till seepage is known to be sensitive to assigned hydraulic conductivity for the till. Higher hydraulic conductivity for the till allows more water to seep downward, and less is left over to discharge horizontally."



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20. Additionally, the hydraulic conductivities for compacted fill materials are known to vary over several orders of magnitude. It is likely that variations in the other soil parameters would also demonstrate a significant influence on the timing of discharge to the creeks. The predicted discharge to the creeks is used to evaluate the low flow deficits resulting from construction of the embankment fill, and ultimately the sizing of the detention vaults for mitigating low flow impacts. Sensitivity of the predicted discharges to the soil parameters and likely to other elements of the model as well (e.g. assumption of vertical flow, number of slices, runoff and infiltration amounts, etc.) suggests the potential for significant uncertainty in the magnitude of the low flow impacts and the sizing of the vaults.

21. **Comment E:** Selection of hydraulic conductivity and moisture retention curves for the Hydrus model based on correlations with average fill characteristics leaves very large margins for error in the results. Specific laboratory tests from representative samples should have been used and a sensitivity analysis should have been performed. Without a sensitivity analysis it is impossible to tell what influence these fluctuations would have on the timing of flow through the embankment.

22. Appendix C of the PGG (2000) report presents the rationale behind selection of fill characteristics for the Hydrus model. Values of hydraulic conductivity (describing the rate at which water flows through soil), moisture retention curves (describing the ability of soil to absorb water around it), and other parameters were estimated based on a selected grain size distribution (the distribution of gravels, sands, silts and clays within any given sample of soil) for the fill material using the Rosetta model. However, the variability of grain size within the fill materials will be enormous,



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and therefore any single set of parameters based on a single assumed grain size distribution is highly unlikely to be representative of the soil mass as a whole.

23. Additionally, limitations in the Rosetta model do not allow for estimation of the hydraulic conductivity and other parameters for materials having a high percentage of gravels (55% of the modeled material was gravel). As such, the estimated parameters were not representative of the selected grain size distribution. As a result, when running the Hydrus model, a further correction had to be performed, involving both the input and output of the model to account for this discrepancy. This added another degree of uncertainty to the analysis.

24. The accuracy of estimated hydraulic conductivities obtained with the Rosetta model was indirectly addressed in the PGG (2000) report:

> "Although the actual value(s) of hydraulic conductivity are not known for this proposed future condition, the value calculated by Rosetta is reasonable for the anticipated texture and density of the general embankment matrix, and is consistent with the two-matrix method of modeling unsaturated flow in the embankment. Experience with testing saturated hydraulic conductivity of soils similar in texture to the modeled fill suggests that the Rosetta-calculated value is too low for the general embankment fill; however, the reason for this discrepancy is the presence of large pores associated with gravels. Large pores associated with gravel deposits dominate saturated flow but are the first to become inactive as drainage occurs."

In essence, the authors are stating that the estimated hydraulic conductivity appears to be lower than typical values encountered in their experience, and further suggest that actual conductivities are controlled by the presence of large pores associated with the presence of gravel. These insights draw into question the entire adequacy of employing the Rosetta estimated parameters, as well as the appropriateness of the modeling approach in how it deals with gravel materials.



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25. The parameters used in the model could have been compared to results from laboratory specimens fabricated to have the selected grain size distribution represented in the model. If the results of the laboratory tests had shown good agreement with the estimated parameters, a measure of confidence could have been gained in the results. Additional laboratory tests should have been performed on different ranges of grain size distribution to yield parameters for different combinations of fill materials, and these parameters should then have been fed into the Hydrus model to evaluate the sensitivity of the flow results to the material type.

26. This sensitivity analysis is critical in light of the model uncertainties. Without it, it is impossible to tell what the impact of parameter variations are, and whether the results are a valid representation of what will occur if the embankment is constructed.

**Embankment Fill Screening Criteria**

27. **Comment F:** The alternative fill criteria allowed in the September 21, 2001, 401 Certification is less protective than earlier criteria presented in the August 10,2001, Certification and does not meet the requirements of the FWS Biological Opinion.

28. The proposed fill will be constructed over a drainage layer designed to carry water that infiltrates through the fill to the base of the embankment and wall. The fill may contain hazardous substances such as chromium, lead, nickel and diesel. A risk exists that water infiltrating through the fill could transport these hazardous substances through the drainage layer and into sensitive areas below the embankment. In order to mitigate this risk, the proposed fill criteria in the 401 Certification dated August 10, 2001 provided more stringent requirements on the concentrations of chromium, lead,



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nickel and diesel that could be placed within the first six feet of the fill adjacent to the drainage layer, and within the six feet below the ground surface.

29. In her declaration Ms. C. Linn Gould states:

> "In addition to the protective soil fill criteria that were developed for the majority of the embankment, the U.S. Fish & Wildlife Service ("FWS") required the Port to construct a 40-foot wedge of fill along the western edge of the embankment that tapers along the natural contours of the underlying soil as it continues to the east, called the "drainage layer cover." ... The protective cover was designed to provide an "ultra-clean" layer of fill which will attenuate any potential contamination that might be leaching through the rest of the embankment above it, thereby giving FWS additional assurance that fill used in the Third Runway embankment would not adversely affect species listed under the Federal Endangered Species Act that may be present in nearby waters." (underlining added for emphasis)

30. This proposed "wedge" alternative is included on page 18 of the September 21, 2001 Department of Ecology revised 401 Certification and is presented as an alternative to the previous soil fill criteria, rather than an addition. The proposed alternative would only apply the more stringent restrictions on the level of hazardous substances in a wedge of fill above the drainage layer that measures 40 feet thick at the base of the embankment and tapers downwards at a 2% slope into the fill. This means that fill above the drainage layer over the upper two thirds of the embankment will contain higher concentrations of hazardous substances than under the original screening criteria. Higher concentrations will also be allowed near the ground surface creating an increased impact on surface water runoff. The alternative clearly represents a reduction of the environmental standards for the project.

31. Under the August 10, 2001 certification requirements, it was felt necessary to completely enclose the higher concentration fill within a six foot layer of fill with more stringent



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screening requirements, although to my knowledge there has been no analysis demonstrating the effectiveness of this method under these conditions. By itself, the alternative proposed in the September 21, 2001 certification represents a relaxation of the requirements, where the upper two thirds of the drainage layer are now exposed. There does not appear to be any rationale given for this relaxation, nor any analysis demonstrating that the wedge of cleaner fill meets an equivalent or more protective standard than the six-foot enclosure.

32. The drainage layer represents a significant pathway for transport of hazardous substances. If fill material with hazardous substances are to be placed in the embankment, the criteria for material placement adjacent to the drainage layer should not be relaxed.

**33. Comment G:** The requirements of the Fish and Wildlife Service (FWS) Biological Opinion are not being fully adhered to in the September 21, 2001 401 Certification. This discrepancy creates the potential for application of a lesser standard than required.

34. In their Biological Opinion, FWS states: "The surficial three feet of fill will be screened to not exceed the Proposed Ecological Standard or MTCA Method A, which ever is less." This requirement for more stringent control over the surficial three feet does not appear to be anywhere within the September 21, 2001 401 Certification, and may in fact be exceeded for chromium, lead, and selenium.

**35. Comment H:** The drainage cover layer can consist of materials that are more "contaminated" than the naturally occurring area soils.



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36. In her declaration Ms. C. Linn Gould states "FWS required that metals in fill used in the drainage layer cover comply with numeric fill criteria equal to background concentrations (when available in the literature) found in the Puget Sound region. ... Therefore, the soil metals used in the drainage layer cover should consist of soil that is no more "contaminated" than naturally occurring area soil." However, when compared to Puget Sound background concentrations contained in the FWS Biological Opinion, the concentration of Arsenic, Cadmium, Lead and Mercury all exceed Puget sound background levels. In addition, Exhibit C of the Gould Declaration shows that Chromium and Nickel also exceed Puget Sound background levels. In the case of Arsenic and Mercury, the levels allowed in the 401 Certification are approximately three times background levels in the Puget Sound area. As illustrated in the table on the following page, of the nine listed contaminants for which natural background levels have been established, the six metals discussed above exceed natural background, in some cases significantly, and none of the contaminants are set at the Practical Quantitation Limits ("PQL") identified in DOE Technical Memorandum #3 PQLS as Cleanup Standards (November 23, 1993) ("Memorandum 3") (copy attached as Exhibit B).

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| Contaminant[1] | 401 Cert. | Puget Sound Background [2] | PQLS[3] |
|---|---|---|---|
| Arsenic | 20 | 7 | 1.5 |
| Beryllium | 0.6 | .6 | .5 |
| Cadmium | 2 | 1 | .1 |
| Chromium | 42/2000 | 48 | .05 |
| Copper | 36 | 36 | .5 |
| Lead | 220/250 | 24 | .5 |
| Mercury | 2 | .07 | .002 |
| Nickel | 100/110 | 48 | 7.5 |
| Selenium | 5 | | .75 |
| Silver | 5 | | .1 |
| Zinc | 85 | 85 | .03 |

The result is that the fill will in fact be more "contaminated" than naturally occurring area soil. The Port has not evaluated the impact of this incremental increase of metals above the drainage layer.

37. **Comment I:** The development of criteria for the drainage layer cover and fill materials are incorrectly based on the assumption that water emerging from the fill will be dispersed in the environment and reach potential ecological receptors at the concentrations assumed. The more realistic

[1] All values listed in milligrams per kilogram ("mg/kg").

[2] As established by DOE publication 94-115 (October 1994).



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scenario is that the water passing through the embankment will be collected in the drainage system and discharged to the creeks at point sources. The more important issue is the concentration of mass of the contaminants and the point discharge into the creeks.

38. The drainage layer under the embankment fill is in essence a blanket drain that collects the seepage through the fill. Without the drainage system the water would be naturally dispersed into the underlying soils and groundwater. With the drainage system the water will be collected in the drainage system and diverted through channels and pipes to the creeks. The concentration of metals or organics in the water discharged from the embankment may be small but the volume of water will be large. The total mass of metals collected at the discharge point to the creeks will correspondingly be larger than would have occurred under conditions without the embankment in place. Over time, the concentration of metals in the creek sediments due to the concentrated discharge of the embankment drainage water will be larger than predicted assuming dispersion of the water seeping through the embankment. The Port's analysis fails to evaluate the ecological impact of this concentrated mass.

**39. Comment J:** The fill source characterization testing protocol in the 401 Certification is not a technically defensible methodology to assure that the environmental fill criteria for the third Runway Embankment Project will be met.

40. As Peter Kmet of the Department of Ecology correctly points out in his e-mail of September 11, 2000 (copy attached as Exhibit C), a sampling program to evaluate the compliance of a site with MTCA or any other standards must meet a statistically acceptable confidence level. The

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[3] These values represent the minimum PQLS in mg/kg as stated in Table II of DOE Memorandum #3 (November 23, 1993).



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number of samples required at a site is dependent on the variability of the results. For example six tests from a borrow site with 100,000 cubic yards of soil with little variability in the results may provide a confidence level of 95% that the fill meets the imposed criteria. However, at a site where six tests have significant variability in their results there may be no more than a 50% level of confidence that the criteria are being met. The Third Runway Embankment project represents an ecologically sensitive project where the contaminant concentration levels of fill placed at the site should meet a minimum confidence level criteria, such as the 95% confidence level discussed by Mr. Kmet. The testing protocol should be changed, particularly for large borrow sources, to provide a known level of confidence that the fill meets the environmental criteria. Without sufficient testing, contaminated fill could be placed leading to environmental impacts that will not be disclosed until after the fill is in-place and the impact has occurred. There are no intermediate check-points between placement of the fill and the measurement of the impact.

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**Conclusions**

41. It has been shown that the fill screening criteria show inconsistencies and gaps in their development and implementation. Additionally, the low flow analyses do not provide results that can be counted on for determining low flow impacts and developing the proposed mitigations. From the foregoing comments, it is clear that there is insufficient evidence that the proposed Third Runway Expansion will result in a system that is protective of the creek and its inhabitants.

I declare under penalty of perjury under the laws of the State of Washington that the foregoing is true and correct.

DATED this 8th day of October, 2001, at Walnut Creek, California.

Patrick Lucia, Ph.D.

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EXHIBIT A

GeoSyntec Consultants

**PATRICK C. LUCIA**

**geotechnical engineering**
**landslides**
**slope stability**

## EDUCATION

University of California: Ph.D., Civil Engineering, 1980
University of California: M.S., Civil Engineering, 1975
University of California: B.S., Civil Engineering, 1974

## REGISTRATION

California Geotechnical Engineering (G.E.) Number GE2033
California Civil Engineer (P.E.) Number C33274

## PROFESSIONAL HISTORY

GeoSyntec Consultants, Walnut Creek, California, Principal, 1993-Present
Woodward-Clyde Consultants, Principal and Vice President, 1984-1993
The Tensar Corporation, Pleasant Hill, California Western Regional Engineer, 1983-1984
Converse Consultants, San Francisco, California, Senior Engineer, 1980-1983
Geotechnical Engineers, Inc., Winchester Massachusetts, Senior Engineer, 1975-1977
Harding Lawson Associates, San Rafael, California, Engineer, 1974
United States Army Corps of Engineers, 1966-1969

## ACADEMIC APPOINTMENTS AND INVITED LECTURES

NATO Advanced Study Institute on Groundwater Pollution Control and Remediation, Invited Lecturer, Kemer, Antalya, Turkey, 1995
National Groundwater Association, In-situ Remediation Course, Lecturer, 1994-1995
American Society of Civil Engineers, San Francisco Section, Remediation/Clean-up of Soil and Groundwater Contamination, Spring 1994 Seminar, Invited Lecturer
Georgia Institute of Technology, 1994 Monie A. Ferst Symposium, Invited Lecturer
University of Wisconsin, Slope Stability Short Course, Lecturer, 1994
University of Wisconsin, In-situ Remediation Short Course, Lecturer, 1993-1994

University of California, Berkeley Extension Program, Member of Advisory Panel on the Certification Program in Remediation, 1992

University of California, Davis, Senior Lecturer, 1990-1991

The Application of United States Pollution Control Technology in Korea, Invited Lecturer, Seoul, Korea, 1989

University of California, Berkeley, Adjunct Lecturer, 1986; Visiting Lecturer, 1984-1986; Research Engineer, 1978-1980; Teaching Assistant, 1977-1978

**OTHER APPOINTMENTS**

San Francisco Bay Conservation and Development Commission, Engineering Criteria Review Board, 1985 to 1996

**REPRESENTATIVE EXPERIENCE**

Dr. Lucia is a civil engineer specializing in the areas of geotechnical engineering and waste management. During more than 25 years of professional practice, he has been responsible for directing a broad range of projects requiring knowledge of foundation and earthquake engineering. Dr. Lucia has worked at various facilities ranging from industrial commercial sites to power plants, and has negotiated with federal, state, and local agencies. In addition, he provides litigation support on environmental and geotechnical matters, and has provided depositions and testimony at trial.

**REPRESENTATIVE PROJECT EXPERIENCE**

- As a member of the San Francisco Bay Conservation and Development Commission Engineering Criteria Review Board, Dr. Lucia served as reviewer for the repairs and upgrade of the Benicia Bridge and the Richardson Bay Bridge. Dr. Lucia also served as reviewer of the seismic analyses and subsequent repairs of the Golden Gate and Bay Bridges following the 1989 Loma Prieta earthquake.

- Investigation and development of recommendations for repair of a 200-foot deep landslide at the Keller Canyon Landfill in Pittsburgh California. Mitigation included construction of a toe buttress and unloading of the head of the landslide requiring the movement of over one million cubic yards of soil.

- Investigation and design of the repair of the San Pablo landslide. Mitigation included installation of horizontal drains up to 600 feet long, excavation and compaction of over one million cubic yards of soil, buttresses up to 120 feet high, drilled piers up to 3 feet in diameter and 60 feet deep, and construction of a 40-foot high, 900-foot long Tensar reinforced earth wall.

- Served as Project Manager for the geotechnical investigation and development of recommendations for lateral earth pressures in a deep excavation, foundation preparation, and handling of contaminated soil and groundwater at a major medical facility in San Francisco, California.

- Provided geotechnical analysis and support to Panama Canal Commission to address landslides that have occurred during the widening of the Panama Canal.

- Foundation investigation and recommendations for the Napa County Courthouse.

- Evaluation of settlement and stability of a proposed shoreline development in Vallejo, California.

- Investigation and development of recommendations for roadway widening in Concord, California.

- Investigation and development of recommendations for sanitary sewer installation and development of a training program for inspectors for the Central Contra Costa Sanitary District.

- Evaluation of building settlement in San Francisco, California.

- Numerous landslide repairs for Marin County Department of Public Works.

- Developed recommendations for the installation of a slurry wall and dewatering system at the Pilgrim Nuclear Power Plant, Plymouth, Massachusetts.

- Evaluated the static and seismic stability of the East Bay Municipal Utilities District's (EBMUD) Mokelume Aqueducts in the San Joaquin Delta region of California.

- Evaluation of the static and seismic stability of EBMUD's Summit Reservoir.

- Developed plans and specifications for five miles of erosion protection at Pacific Gas & Electric Company's Bass Lake Reservoir in Northern California.

- Siting study, site characterization, and preparation of preliminary plans, specifications, and cost estimates for four (4) landfill sites in Sonoma County, California.

- Site characterization, preparation of plans and specifications for the proposed 600 foot high Kirker Pass Landfill, Contra Costa County, California.

- Provided review and testimony before the State Water Resources Control Board on the stability of the Keller Canyon Landfill, Contra Costa County, California.

- Design of a geosynthetic reinforced buttress to stabilize portions of the Operating Industries Landfill in Monterey Park, California.

**REPRESENTATIVE LITIGATION SUPPORT**

- On behalf of counsel for a geotechnical engineering firm, provided expert testimony in deposition and trial for litigation involving the Discovery Bay residential development in the San Joaquin Delta region of California. Testimony concerned the cause of slope settlement and the engineers' compliance with the Standard of Care.

- Provided expert testimony in deposition and trial on the probability of failure and potential remediation costs for over 20 landslides at the Rancho Solano development in Fairfield, California.

- Provided expert testimony in deposition for litigation involving a major landslide at a housing development in San Ramon, California. Testimony concerned the cause of failure, and the geotechnical engineer's compliance with the Standard of Care.

- Provided expert testimony in deposition and in arbitration for a $3.5M claim concerning the cause of failure of several retaining structures in the geysers area of Northern California. Addressed contractor compliance with plans and specifications.

- Provided expert testimony representing the contractor in depositions and in arbitration in a $2.5M claim relative to the cause of pipeline settlement and contractor compliance with plans and specifications for a project in Pleasanton, California.

- Provided expert testimony in nonbinding arbitration in a $250,000 changed condition claim representing the contractor in a pipeline construction project in Santa Clara County.

- Provided expert testimony in deposition and trial in San Mateo County representing a homeowner regarding settlement of a building due to construction adjacent to the property.

- Provided litigation support representing the developer of a condominium project in Contra Costa County. Evaluated the cause of settlement, probable mitigation alternatives and cost of foundation repair of the buildings.

- Provided litigation support to a geotechnical engineering firm regarding settlement of numerous buildings in a condominium project in San Mateo County. Evaluated cause of settlement, amount of settlement remaining over the next 30 years and reasonable mitigation alternatives.

- Currently providing litigation support for cost allocation and the likely sources of PCE and TCE in groundwater on behalf of counsel representing a manufacturing facility in Mountain View, California.

- Provided expert testimony in deposition on the allocation of cost and closure alternatives for a landfill with an extensive volatile organic compound (VOC) contaminated groundwater plume in Ventura County, California.

- Served as a member of the Board of Consultants charged with reviewing the closure design for a hazardous and low-level radioactive waste landfill including stabilization and closure of surface impoundments, in West Chicago, Illinois. Provided expert testimony in trial and in hearings before the Nuclear Regulatory Commission.

- On behalf of counsel to a potentially responsible party (PRP), provided expert testimony in trial on causes of lead contamination at the Point Isabel site in Richmond, California.

- Provided expert testimony in deposition and mediation on alternatives and remediation costs at a site in Sacramento, California, contaminated with over 700 cubic yards of battery casings.

- Provided expert testimony in deposition on remedial alternatives and remediation costs concerning a lead-contaminated site in San Francisco, California.

- On behalf of counsel representing municipalities, provided review and expert testimony in deposition on the remediation, closure methods, and estimated cost of closure for a Class II landfill in Richmond, California.

## AFFILIATIONS

American Society of Civil Engineers
Society of American Military Engineers
Tau Beta Pi
Phi Beta Kappa

## RECENT PUBLICATIONS

"*Evaluation of Remedial System and Strategies*", Invited paper presented at the NATO Advanced Study Institute on Groundwater Pollution Control and Remediation, Turkey, 1995.

"*Design of Landfills*", Invited paper presented at the Application of U.S. Pollution Control Technology in Korea, Conference on Solid and Hazardous Waste Technology, Seoul, Korea, 1989.

"*Application of GeoSynthetics in Waste Management*", Invited paper presented at the Application of U.S. Pollution Control Technology in Korea, Conference on Solid and Hazardous Waste Technology, Seoul, Korea, 1989.

EXHIBIT B

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DEPARTMENT OF ECOLOGY

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November 24, 1993

Implementation Memo No. 3

TO: Interested Staff

FROM: Steve Robb

Toxics Cleanup Program

SUBJECT: PQLs as Cleanup Standards

ISSUES

Two issues have been raised with regard to the use of practical quantitation limits (PQLs) in setting cleanup levels:

- The "legal" issue of PQLs as cleanup levels and whether or not PLPs have any long-term liability for sites cleaned up to the PQL level rather than the risk-based level. Can PLPs receive a covenant not to sue in these situations? Are they required to utilize institutional controls and conduct long-term monitoring?
- When risk-based compliance values are less than PQLs, what value is used in the risk summation calculation, the risk-based value or the PQL?

I. LONG-TERM LIABILITY

The Model Toxics Control Act (MTCA) states, "Where cleanup levels are below the PQL, compliance with cleanup standards will be based upon the PQL" (WAC 173-340-700(6) Measuring compliance). Also stated in the rule, "If those situations arise and the practical quantitation limit is higher than the cleanup level for that substance, the cleanup level shall be considered to have been attained, subject to subsection (4) of this section..." (WAC 173-340-707(2) Analytical considerations). Therefore, the PQL becomes the compliance value, and PLPs who attain the PQL are eligible for a covenant not to sue. WAC 173-340-707(4) places one additional burden, however, and that is a requirement for periodic review of the cleanup action in which the department, in reviewing the cleanup action, shall "...consider the availability of improved analytical techniques." Therefore, any covenant must have a reopener which would allow the department to take action if necessary.

Long-term monitoring is not required as long as the remedy does not specifically involve containment. However, it is possible that the remaining unquantified risk at a site could be sufficient to cause concern. This situation makes it very important for project managers to require PLPs to attempt to quantify those contaminants which have high PQLs. We need to avoid situations in which PLPs may leave unquantified contamination and that upon periodic review new analytical data demonstrates that further action is necessary. The rule supports the use of special analytical methods and/or institutional

controls to address this situation.

WAC 173-340-707(3) gives project managers the flexibility to require special sampling and analytical methods. PQLs should not be used to justify unnecessarily high compliance levels. In cases where the risk-based cleanup level is less than the PQL, site managers should calculate, using the appropriate formula, the risk the contaminant would represent if it were present at the PQL concentration. As this risk approaches the 1x10-5 level, serious consideration should be given to use of surrogate measures of the hazardous substance or development of specialized sample collection and/or analysis techniques. If the risk posed by a contaminant concentration at the PQL level exceeds the 1x10-5 level, project managers should consider requiring special analytical methods which can quantify the contaminant concentration at least to the 1x10-5 level.

In support of this approach, the Responsiveness Summary (RS) acknowledges that in meeting its mission to protect human health and the environment, Ecology cannot ignore concentrations below current quantitation limits. In doing so, the RS states, we would be placing "...human health and the environment 'at the mercy of analytic quantitation limits' and would be inconsistent with the statute's overriding objectives" (p. 107).

Finally, WAC 173-340-440(1)(a) requires institutional controls "...when the department determines such controls are required to assure the continued protection of human health and the environment or the integrity of the cleanup action." In situations where the PQL is above cleanup levels (i.e. exceed the 1x10-5 level), project managers should evaluate the need for institutional controls, particularly if special analytical methods are inadequate.

II. RISK SUMMATION CALCULATIONS BASED ON PQLs

MTCA requires the development of cleanup levels that are protective of human health and the environment. For carcinogenic substances, protection is defined as a cumulative site risk that does not exceed 1 in 100,000 (1x10-5). However, our inability to reliably measure some contaminant concentrations at calculated risk-based levels hinders our ability to measure total site risk.

In some situations the risk posed by a single contaminant at the PQL concentration outweighs the risk of all the other contaminants put together. Using such a PQL risk value in the risk summation calculation will negate the usefulness of both the risk summation and the 1x10-5 cumulative site risk requirement. In this situation, to calculate overall site risk, use the risk-based cleanup level rather than the PQL. The other contaminant concentrations can then be adjusted downward, as necessary, so the adjusted total site risk does not exceed 1x10-5. The final list of compliance levels should show the single contaminant at the PQL value and the other contaminants at their adjusted levels.

When adjusting individual cleanup levels to meet the one in a hundred thousand total risk standard at sites with multiple contaminants becomes necessary, do not adjust a contaminant below its PQL. For example, the cleanup level for trichloroethylene (TCE) in groundwater is 3.98 ppb and the PQL is 0.5 ppb. If higher cleanup levels for other compounds required the TCE cleanup level to be adjusted downward, it should not be adjusted below 0.5 ppb.

One final clarification regarding risk summation is warranted. Method B specifically establishes cleanup levels based on a risk of one in a million for individual carcinogenic contaminants. When multiple contaminants and/or multiple pathways of exposure are involved, MTCA allows for a cumulative site risk of no more than one in a hundred thousand (e.g., WAC 173-340-720(5)). The one

in a hundred thousand risk level is intended to serve as a cap, or ceiling, on the cumulative site risk at cleanup sites with multiple contaminants and is not a goal.

For example, when the cumulative site risk total is 8x10-5, cleanup levels for individual constituents must be adjusted downward until the cumulative site risk is equal to or less than 1x10-5. Alternately, at sites where the total cumulative site risk is 8x10-6, for example, no downward adjustment is necessary, since the risk does not exceed 1x10-5. However, adjustment upward for individual contaminants is not permitted under MTCA since individual contaminants must still meet the 1x10-6 (or 1x10-5 for Method C) limit.

Risk Communication

How we portray risk to the public is important to the implementation of the rules. When cleanup levels are based on PQL values, Ecology site managers should explain that technical limitations may prohibit us from measuring contaminants at levels that correspond to a risk of 1x10-6. This explanation should be part of the Cleanup Action Plan (CAP) and any public hearings where cleanup levels and risk are discussed. The CAP should include a list of risk-based levels as well as a list of the compliance levels.

Analytical Guidelines

- Know your expected PQLs. Communicate with your laboratory if you have any doubts, special expectations, or special analytical needs. Before your analytical work is requested, be sure that the results to be provided by your laboratory will meet your requirements.
- With the analytical results, the estimates of the PQLs for each sample matrix along with an explanation of how the PQL was determined should be provided by the laboratory.
- Appropriate quality assurance and quality control (QA/QC) data should be provided by the laboratory for all sets of samples.

What Are The PQLs?

There is no definitive list of PQLs. However, Ecology has put together tables of PQLs, MDLs (method detection limits), and comparisons to Method B numbers for groundwater, surface water, and soil. These tables are based on surveying published methods and laboratories. There are many factors that can produce a different PQL for one sample as compared to another. However, these tables can be useful guidance. Ecology refers you to the guidance for the use of the tables and also to a discussion on the meaning of PQLs. These are found as three additional parts to this memorandum. The four parts are:

Part I: Implementation Memo No. 3--PQLs as Cleanup Standards (this document)

Part II: Guidance For The Use of Tables

Part III: MDL, PQL, and Comparisons Tables

*NOTE TO USERS: The following links on this page are to Microsoft Excel documents. Windows users who do not have Microsoft Excel may view and print these documents with Excel Viewer which is available to download via FTP from Microsoft. Please note: the downloadable documents are not available for either Macintosh or Unix systems.*

- Table I: Water
- Table II: Soil

Part IV: Appendix--Meaning of Quantitation Limits

Return to PQL/MCL Index

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| TABLE II: SOIL | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MDLs, PQLs, and Comparison of Method B Values | | | | | | | | | | | |
| | | | Lab PQL Range < Published PQL | | | | | | | | |
| CAS | Chemical | Method | Dectector | PQL (mg/kg) | | LABORATORY PQL RANGE (mg/kg) | | | 10e-6 Method B Soil Value (mg/kg) | PQL > Soil Method B (flag=na) | |
| 83-32-9 | acenaphth | 8270 | GC/MS | 0.66 | | 0.013 | - | 0.66 | | | |
| 83-32-9 | acenaphth | 8310 | HPLC | 1.2 | | 0.017 | - | 1.2 | | | |
| 208-96-8 | acenaphth | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | n/c | | |
| 208-96-8 | acenaphth | 8310 | HPLC | 1.5 | | 0.017 | - | 1.5 | n/c | | |
| 67-64-1 | acetone | 8240 | GC/MS | 0.01 | | 0.001 | - | 0.05 | | | |
| 107-02-8 | acrolein | 8030 | GC-FID | 0.007 | | 0.001 | - | 0.01 | | | |
| 79-06-1 | acrylamide | 8015 | GC-FID | | | | | | 2.22E-1 | | |
| 107-13-1 | acrylonitri | 8030 | GC-FID | 0.005 | | 0.001 | - | 0.05 | 1.85E+0 | | |
| 5972-60-8 | alachlor | 505.2 | GC-ECD | 0.01 | | | | | 1.23E+1 | | |
| 116-06-3 | aldicarb | 531.1 | HPLC | 0.5 | | | | | | | |
| 309-00-2 | aldrin | 8080 | GC-ECD | 0.003 | | 0.0017 | - | 0.003 | 5.88E-2 | | |
| 62-53-3 | aniline | 8270 | GC/MS | 0.66 | | 0.067 | - | 0.66 | 1.75E+2 | | |
| 120-12-7 | anthracen | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | | | |
| 120-12-7 | anthracen | 8310 | HPLC | 0.009 | | 0.005 | - | 0.009 | | | |
| 7440-36-0 | antimony | 6010 | ICP | 16 | | 1.5 | - | 10 | | | |
| 7440-36-0 | antimony | 7041 | AA | 1.5 | | 0.00025 | - | 1 | | | |
| 140-57-8 | aramite | 8270 | GC/MS | | | | | | 4.00E+1 | | |
| 2674-11-2 | Aroclor 10 | 8080 | GC-ECD | 0.044 | | 0.017 | - | 0.1 | | | |
| 1104-28-2 | Aroclor 12 | 8080 | GC-ECD | 0.044 | | 0.017 | - | 0.1 | n/c | | |
| 1141-16-5 | Aroclor 12 | 8080 | GC-ECD | 0.044 | | 0.017 | - | 0.1 | n/c | | |
| 3469-21-9 | Aroclor 12 | 8080 | GC-ECD | 0.044 | | 0.017 | - | 0.1 | n/c | | |
| 2672-29-6 | Aroclor 12 | 8080 | GC-ECD | 0.044 | | 0.017 | - | 0.1 | n/c | | |
| 1097-69-1 | Aroclor 12 | 8080 | GC-ECD | 0.088 | | 0.017 | - | 0.1 | n/c | | |
| 1096-82-5 | Aroclor 12 | 8080 | GC-ECD | 0.088 | | 0.017 | - | 0.1 | n/c | | |
| 7440-38-2 | arsenic | 6010 | ICP | 25 | | 2.5 | - | 10 | 1.43E+0 | | |
| 7440-38-2 | arsenic | 7060 | GFAA | 0.5 | | 0.00025 | - | 0.5 | 1.43E+0 | | |
| 7440-38-2 | arsenic | 7061 | GHAA | 1 | | | | | 1.43E+0 | | |
| 1332-21-4 | asbestos | | | | | | | | | | |
| 1912-24-9 | atrazine | 619 | GC/NP | 0.05 | | | | | 4.55E+0 | | |
| 103-33-3 | azobenzen | 8270 | GC/MS | 0.33 | | 0.033 | - | 0.33 | 9.09E+0 | | |
| 56-55-3 | benz[a]an | 8270 | GC/MS | 0.66 | | 0.0055 | - | 0.66 | 1.37E-1 | | |
| 56-55-3 | benz[a]an | 8310 | HPLC | 0.009 | | 0.005 | - | 0.009 | 1.37E-1 | | |
| 71-43-2 | benzene | 8020 | GC-PID | 0.002 | | 0.001 | - | 0.04 | 3.45E+1 | | |
| 71-43-2 | benzene | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 3.45E+1 | | |
| 92-87-5 | benzidine | 8250 | GC/MS | 29 | | 0.8 | - | 29 | 4.35E-3 | | |
| 50-32-8 | benzo[a]p | 8270 | GC/MS | 0.66 | | 0.005 | - | 0.66 | 1.37E-1 | | |
| 50-32-8 | benzo[a]p | 8310 | HPLC | 0.015 | | 0.005 | - | 0.015 | 1.37E-1 | | |
| 205-99-2 | benzo[b]fl | 8270 | GC/MS | 0.66 | | 0.005 | - | 0.66 | 1.37E-1 | | |
| 205-99-2 | benzo[b]fl | 8310 | HPLC | 0.012 | | 0.005 | - | 0.012 | 1.37E-1 | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 191-24-2 | benzo[g,h | 8270 | GC/MS | 0.66 | | 0.01 | - | 0.66 | n/c | |
| 191-24-2 | benzo[g,h | 8310 | HPLC | 0.051 | | 0.01 | - | 0.051 | n/c | |
| 207-08-9 | benzo[k]fl | 8270 | GC/MS | 0.66 | | 0.005 | - | 0.66 | 1.37E-1 | |
| 207-08-9 | benzo[k]fl | 8310 | HPLC | 0.011 | | 0.005 | - | 0.011 | 1.37E-1 | |
| 65-85-0 | benzoic ac | 8270 | GC/MS | 3.3 | | 0.1 | - | 3.3 | | |
| 98-07-7 | benzotrich | 8270/8010 | -MS/GC-H | 0.05 | | 0.05 | - | 0.33 | 7.69E-2 | |
| 100-51-6 | benzyl alc | 8270 | GC/MS | 1.3 | | 0.033 | - | 1.7 | | |
| 100-44-7 | benzyl chl | 8240 | GC/MS | 0.1 | | 0.1 | - | 0.33 | 5.88E+0 | |
| 7440-41-7 | beryllium | 6010 | ICP | 0.15 | | 0.125 | - | 0.25 | 2.33E-1 | |
| 7440-41-7 | beryllium | 7091 | GFAA | 0.1 | | 0.125 | - | 0.25 | 2.33E-1 | |
| 111-91-1 | bis(2-chlo | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | n/c | |
| 111-44-4 | bis(2-chlo | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | 9.09E-1 | |
| 9638-32-9 | bis(2-chlo | 8270 | GC/MS | 0.66 | | 0.067 | - | 0.66 | | |
| 117-81-7 | bis(2-ethy | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | 7.14E+1 | |
| 542-88-1 | bis(chloro | 8270 | GC/MS | 0.66 | | 0.01 | - | 0.66 | 4.55E-3 | |
| 75-27-4 | bromodich | 8010 | GC-Hall | 0.001 | | 0.001 | - | 0.1 | 1.61E+1 | |
| 75-27-4 | bromodich | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 1.61E+1 | |
| 75-25-2 | bromoform | 8010 | GC-Hall | 0.002 | | 0.001 | - | 0.5 | 1.27E+2 | |
| 75-25-2 | bromoform | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 1.27E+2 | |
| 101-55-3 | bromophe | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | n/c | |
| 85-68-7 | butyl benz | 8060 | GC-FID | 10 | | | | | | |
| 85-68-7 | butyl benz | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | | |
| 85-68-7 | butyl benz | | GC-ECD | 0.23 | | | | | | |
| 7440-43-9 | cadmium | 6010 | ICP | 2 | | 0.01 | - | 1 | | |
| 7440-43-9 | cadmium | 7130 | GFAA | 0.05 | | 0.05 | - | 0.25 | | |
| 86-74-8 | carbazole | 8270 | GC/MS | 0.33 | | | | | 5.00E+1 | |
| 1563-66-2 | carbofuran | 632 | HPLC | 0.83 | | | | | | |
| 75-15-0 | carbon dis | 8240 | GC/MS | 0.1 | | 0.001 | - | 0.05 | | |
| 56-23-5 | carbon tet | 8010 | GC-Hall | 0.001 | | 0.001 | - | 0.01 | 7.69E+0 | |
| 56-23-5 | carbon tet | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 7.69E+0 | |
| 57-74-9 | chlordane | 8080 | GC-ECD | 0.009 | | 0.009 | - | 0.05 | 7.69E-1 | |
| | chlordane | 8080 | GC-ECD | 0.01 | | 0.0017 | - | 0.01 | n/c | |
| | chlordane | 8080 | GC-ECD | 0.01 | | 0.0017 | - | 0.01 | n/c | |
| 3165-93-3 | chloro-2-m | 8270 | GC/MS | 0.66 | | 0.33 | - | 0.66 | 2.17E+0 | |
| 95-69-2 | chloro-2-m | 8270 | GC/MS | 0.66 | | 0.66 | - | 1.7 | 1.72E+0 | |
| 59-50-7 | chloro-3-m | 8040 | GC-ECD | 1.2 | | | | | n/c | |
| 59-50-7 | chloro-3-m | 8040 | GC-FID | 0.24 | | | | | n/c | |
| 106-47-8 | chloroanil | 8270 | GC/MS | 0.33 | | 0.067 | - | 0.33 | | |
| 108-90-7 | chloroben | 8010 | GC-Hall | 0.003 | | 0.001 | - | 0.025 | | |
| 108-90-7 | chloroben | 8020 | GC-PID | 0.002 | | 0.001 | - | 0.01 | | |
| 108-90-7 | chloroben | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | | |
| 124-48-1 | chlorodibr | 8010 | GC-Hall | 0.002 | | 0.001 | - | 0.1 | 1.19E+1 | |
| 75-00-3 | chloroetha | 8010 | GC-Hall | 0.005 | | 0.001 | - | 0.5 | | |
| 75-00-3 | chloroetha | 8240 | GC/MS | 0.01 | | 0.001 | - | 0.01 | | |
| 110-75-8 | chloroethy | 8010 | GC-Hall | 0.001 | | 0.001 | - | 0.5 | n/c | |
| 110-75-8 | chloroethy | 8240 | GC/MS | 0.01 | | 0.001 | - | 0.01 | n/c | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 67-66-3 | chloroform | 8010 | GC-Hall | 0.0005 | | 0.0005 | - | 0.05 | 1.64E+2 | |
| 67-66-3 | chloroform | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 1.64E+2 | |
| 74-87-3 | chloromet | 8010 | GC-Hall | 0.0008 | | 0.0008 | - | 0.5 | 7.69E+1 | |
| 74-87-3 | chloromet | 8240 | GC/MS | 0.01 | | 0.001 | - | 0.01 | 7.69E+1 | |
| 91-58-7 | chloronap | 8120 | GC-Hall | 0.63 | | 0.33 | - | 0.63 | n/c | |
| 91-58-7 | chloronap | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | n/c | |
| 88-73-3 | chloronitro | 8270 | GC/MS | 0.66 | | 0.33 | - | 0.66 | 4.00E+1 | |
| 100-00-5 | chloronitro | 8270 | GC/MS | 0.66 | | 0.33 | - | 0.66 | 5.56E+1 | |
| 95-57-8 | chlorophe | 8040 | GC-FID | 0.21 | | 0.33 | - | 1.5 | | |
| 95-57-8 | chlorophe | 8270 | GC/MS | 0.66 | | 0.17 | - | 0.66 | | |
| 95-57-8 | chlorophenol;2- | | GC-ECD | 0.39 | | 0.067 | - | 0.39 | | |
| 7005-72-3 | chlorophe | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | n/c | |
| 1897-45-6 | chlorthalo | 8080 | GC-ECD | 0.01 | | 0.0083 | - | 0.01 | 9.09E+1 | |
| 6065-83-1 | chromium | 3050/7190 | FAA | 25 | | 0.25 | - | 1 | | |
| 6065-83-1 | chromium | 3050/7191 | GFAA | 0.5 | | 0.25 | - | 0.5 | | |
| 7440-47-3 | chromium(VI) (**) | | | | | | | | n/c | |
| 218-01-9 | chrysene | 8270 | GC/MS | 0.66 | | 0.01 | - | 0.66 | 1.37E-1 | |
| 218-01-9 | chrysene | 8310 | HPLC | 0.1 | | 0.01 | - | 0.1 | 1.37E-1 | |
| 7440-50-8 | copper | 6010 | ICP | 3 | | 0.5 | - | 1 | | |
| 7440-50-8 | copper | 7211 | GFAA | 0.5 | | | | | | |
| 108-39-4 | cresol;m- | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | | |
| 95-48-7 | cresol;o- | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | | |
| 106-44-5 | cresol;p- | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | | |
| 57-12-5 | cyanide | | | | | | | | | |
| 57-12-5 | cyanide | M4500-CN | color | 5 | | 0.5 | - | 5 | | |
| 75-99-0 | dalapon, s | 8150 | GC-ECD | 1.2 | | 0.1 | - | 1.2 | | |
| 94-82-6 | DB;2,4- | 8150 | GC-ECD | 0.18 | | | | | | |
| 72-54-8 | DDD;p,p'- | 8080 | GC-ECD | 0.007 | | 0.0017 | - | 0.007 | 4.17E+0 | |
| 72-55-9 | DDE;p,p'- | 8080 | GC-ECD | 0.003 | | 0.0017 | - | 0.1 | 2.94E+0 | |
| 50-29-3 | DDT;p,p'- | 8080 | GC-ECD | 0.008 | | 0.0017 | - | 0.1 | 2.94E+0 | |
| 84-74-2 | di-n-butyl | 8060 | GC-ECD | 0.004 | | | | | | |
| 84-74-2 | di-n-butyl | 8270 | GC/MS | 1.7 | | 0.033 | - | 1.7 | | |
| 117-84-0 | di-n-octyl | 8060 | GC-ECD | 0.03 | | | | | | |
| 117-84-0 | di-n-octyl | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | | |
| 2303-16-4 | diallate | 8150 | GC-ECD | 0.15 | | | | | 1.64E+1 | |
| 333-41-5 | diazinon | 8140 | GC-FPD | 0.12 | | 0.0017 | - | 0.033 | | |
| 53-70-3 | dibenz[a,h | 8270 | GC/MS | 0.66 | | 0.01 | - | 0.66 | 1.37E-1 | |
| 53-70-3 | dibenz[a,h | 8310 | HPLC | 0.02 | | 0.01 | - | 0.66 | 1.37E-1 | |
| 132-64-9 | dibenzofu | 8270 | GC/MS | 0.33 | | 0.033 | - | 0.33 | | |
| 124-48-1 | dibromoch | 8010 | GC-Hall | 0.0009 | | 0.0009 | - | 0.1 | 1.19E+1 | |
| 124-48-1 | dibromoch | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 1.19E+1 | |
| 124-48-1 | dibromoch | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 1.19E+1 | |
| 1918-00-9 | dicamba | 8150 | GC-ECD | 0.054 | | 0.01 | - | 0.3 | | |
| 95-50-1 | dichlorobe | 8010 | GC-Hall | 0.0015 | | 0.0015 | - | 0.1 | | |
| 95-50-1 | dichlorobe | 8020 | GC-PID | 0.004 | | 0.004 | - | 0.01 | | |
| 95-50-1 | dichlorobe | 8120 | GC-ECD | 0.76 | | 0.01 | - | 0.76 | | |

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|---|---|---|---|---|---|---|---|---|---|---|
| 95-50-1 | dichlorobe | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | | |
| 541-73-1 | dichlorobe | 8010 | GC-Hall | 0.0032 | | 0.0032 | - | 0.33 | n/c | |
| 541-73-1 | dichlorobe | 8020 | GC-PID | 0.004 | | 0.004 | - | 0.33 | n/c | |
| 541-73-1 | dichlorobe | 8120 | GC-ECD | 0.8 | | 0.01 | - | 0.8 | n/c | |
| 541-73-1 | dichlorobe | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | n/c | |
| 106-46-7 | dichlorobe | 8010 | GC-Hall | 0.0024 | | 0.0024 | - | 0.33 | 4.17E+1 | |
| 106-46-7 | dichlorobe | 8020 | GC-PID | 0.003 | | 0.003 | - | 0.33 | 4.17E+1 | |
| 106-46-7 | dichlorobe | 8120 | GC-ECD | 0.9 | | 0.33 | - | 0.9 | 4.17E+1 | |
| 106-46-7 | dichlorobe | 8270 | GC/MS | 0.66 | | 0.01 | - | 0.66 | 4.17E+1 | |
| 91-94-1 | dichlorobe | 8270 | GC/MS | 1.3 | | 0.033 | - | 1.3 | 2.22E+0 | |
| 75-71-8 | dichlorodi | 8010 | GC-Hall | 0.002 | | 0.001 | - | 0.02 | | |
| 75-71-8 | dichlorodi | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.05 | | |
| 75-34-3 | dichloroet | 8010 | GC-Hall | 0.0007 | | 0.0007 | - | 0.01 | | |
| 75-34-3 | dichloroet | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.1 | | |
| 107-06-2 | dichloroet | 8010 | GC-Hall | 0.0003 | | 0.0003 | - | 0.01 | 1.10E+1 | |
| 107-06-2 | dichloroet | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.1 | 1.10E+1 | |
| 156-60-5 | dichloroet | 8010 | GC-Hall | 0.001 | | 0.001 | - | 0.05 | | |
| 156-60-5 | dichloroet | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | | |
| 75-35-4 | dichloroet | 8010 | GC-Hall | 0.001 | | 0.001 | - | 0.05 | 1.67E+0 | |
| 75-35-4 | dichloroet | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 1.67E+0 | |
| 540-59-0 | dichloroet | 8010 | GC-Hall | 0.001 | | 0.001 | - | 0.01 | n/c | |
| 540-59-0 | dichloroet | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | n/c | |
| 156-59-2 | dichloroet | 8010 | GC-Hall | 0.001 | | 0.001 | - | 0.01 | | |
| 156-59-2 | dichloroet | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | | |
| 120-83-2 | dichloroph | 8040 | GC-FID | 0.26 | | 0.033 | - | 0.33 | | |
| 120-83-2 | dichloroph | 8270 | GC/MS | 0.66 | | 0.033 | - | 1.7 | | |
| 120-83-2 | dichlorophenol;2,4- | | GC-ECD | 0.46 | | | | | | |
| 94-75-7 | dichloroph | 8150 | GC-ECD | 0.24 | | 0.04 | - | 1 | | |
| 78-87-5 | dichloropr | 8010 | GC-Hall | 0.0004 | | 0.0004 | - | 0.1 | 1.47E+1 | |
| 78-87-5 | dichloropr | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 1.47E+1 | |
| 542-75-6 | dichloropr | 8010 | GC-Hall | 0.003 | | 0.001 | - | 0.01 | 5.56E+0 | |
| 542-75-6 | dichloropr | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 5.56E+0 | |
| | dichloropr | 8010 | GC-Hall | 0.003 | | 0.001 | - | 0.2 | n/c | |
| | dichloropr | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | n/c | |
| | dichloropr | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.1 | n/c | |
| | dichloropr | 8010 | GC-Hall | 0.003 | | 0.001 | - | 0.01 | n/c | |
| 60-57-1 | dieldrin | 8080 | GC-ECD | 0.001 | | 0.001 | - | 0.01 | 6.25E-2 | |
| 84-66-2 | diethyl ph | 8060 | GC-FID | 21 | | | | | | |
| 84-66-2 | diethyl ph | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | | |
| 84-66-2 | diethyl phthalate | | GC-ECD | 0.33 | | | | | | |
| 119-90-4 | dimethoxy | 8270 | GC/MS | 1 | | 0.33 | - | 1 | 7.14E+1 | |
| 131-11-3 | dimethyl p | 8060 | GC-FID | 13 | | | | | | |
| 131-11-3 | dimethyl p | 8270 | GC/MS | 0.66 | | 0.01 | - | 0.66 | | |
| 131-11-3 | dimethyl phthalate | | GC-ECD | 0.19 | | 0.19 | - | 0.33 | | |
| 119-93-7 | dimethylb | 8270 | GC/MS | 1 | | 0.33 | - | 1 | 1.09E-1 | |
| 540-73-8 | dimethylh | 8270 | GC/MS | 1 | | 1 | - | 1.7 | 7.14E-4 | |

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|---|---|---|---|---|---|---|---|---|---|---|
| 105-67-9 | dimethylp | 8040 | GC-FID | 0.21 | | | | | | |
| 105-67-9 | dimethylp | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | | |
| 105-67-9 | dimethylphenol;2,4- | | GC-ECD | 0.42 | | | | | | |
| 534-52-1 | dinitro-o-c | 8270 | GC/MS | 3.3 | | 0.033 | - | 3.3 | n/c | |
| 51-28-5 | dinitrophe | 8040 | GC-FID | 8.7 | | 0.067 | - | 8.7 | | |
| 51-28-5 | dinitrophe | 8270 | GC/MS | 3.3 | | 0.067 | - | 3.3 | | |
| 121-14-2 | dinitrotolu | 8090 | GC-ECD | 0.013 | | 0.013 | - | 0.33 | | |
| 121-14-2 | dinitrotolu | 8270 | GC/MS | 0.66 | | 0.013 | - | 0.66 | | |
| 606-20-2 | dinitrotolu | 8090 | GC-ECD | 0.007 | | 0.007 | - | 0.66 | | |
| 606-20-2 | dinitrotolu | 8270 | GC/MS | 0.66 | | 0.013 | - | 0.66 | | |
| 88-85-1 | dinoseb | 8150 | GC-ECD | 0.014 | | 0.0017 | - | 0.05 | | |
| 88-85-1 | dinoseb | 8270 | GC/MS | | | | | | | |
| 123-91-1 | dioxane;1, | 8240 | GC/MS | 0.01 | | 0.01 | - | 0.5 | 9.09E+1 | |
| 122-66-7 | diphenylh | 8270 | GC/MS | 0.66 | | 0.067 | - | 0.66 | 1.25E+0 | |
| 298-04-4 | disulfoton | 8140 | GC-FPD | 0.13 | | 0.0017 | - | 0.13 | | |
| 298-04-4 | disulfoton | 8270 | GC/MS | | | | | | | |
| | endosulfa | 8080 | GC-ECD | | | | | | n/c | |
| | endosulfa | 8080 | GC-ECD | 0.009 | | 0.0017 | - | 0.1 | n/c | |
| | endosulfa | 8080 | GC-ECD | 0.003 | | 0.0017 | - | 0.1 | n/c | |
| 1031-07-8 | endosulfa | 8080 | GC-ECD | 0.044 | | 0.0017 | - | 0.1 | n/c | |
| 145-73-3 | endothall | | | | | | | | | |
| 72-20-8 | endrin | 8080 | GC-ECD | 0.004 | | 0.0017 | - | 0.1 | | |
| 3494-70-5 | endrin ket | 8250 | GC/MS | | | | | | n/c | |
| 106-89-8 | epichlorohydrin | | | | | | | | 1.01E+2 | |
| 140-88-5 | ethyl acryl | 8020 | GC-PID | 0.1 | | 0.1 | - | 0.33 | 2.08E+1 | |
| 100-41-4 | ethylbenze | 8020 | GC-PID | 0.002 | | 0.001 | - | 0.04 | | |
| 100-41-4 | ethylbenze | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | | |
| 106-93-4 | ethylene d | 8011 | GC/ECD | 0.002 | | 0.002 | - | 0.005 | 1.18E-2 | |
| 107-21-1 | ethylene g | 8240 | GC-FID | 10 | | 0.33 | - | 10 | | |
| 96-45-7 | ethylene th | *632 | HPLC | | | | | | 2.78E+1 | |
| 206-44-0 | fluoranthe | 8270 | GC/MS | 0.66 | | 0.005 | - | 0.66 | | |
| 206-44-0 | fluoranthe | 8310 | HPLC | 0.14 | | 0.01 | - | 0.14 | | |
| 86-73-7 | fluorene | 8270 | GC/MS | 0.66 | | 0.005 | - | 0.66 | | |
| 86-73-7 | fluorene | 8300 | HPLC | 0.14 | | 0.005 | - | 0.14 | | |
| 133-07-3 | folpet | | | | | | | | 2.86E+2 | |
| 67-45-8 | furazolidone | | | | | | | | 2.63E-1 | |
| 531-82-8 | furium | | | | | | | | 2.00E-2 | |
| 76-44-8 | heptachlo | 8080 | GC-ECD | 0.002 | | 0.0017 | - | 0.1 | 2.22E-1 | |
| 1024-57-3 | heptachlo | 8080 | GC-ECD | 0.056 | | 0.0017 | - | 0.1 | 1.10E-1 | |
| 118-74-1 | hexachlor | 8120 | GC-ECD | 0.034 | | 0.034 | - | 0.33 | 6.25E-1 | |
| 118-74-1 | hexachlor | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | 6.25E-1 | |
| 87-68-3 | hexachlor | 8120 | GC-ECD | 0.23 | | 0.23 | - | 0.33 | 1.28E+1 | |
| 87-68-3 | hexachlor | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | 1.28E+1 | |
| 319-84-6 | hexachlor | 8080 | GC-ECD | 0.002 | | 0.0017 | - | 0.002 | 1.59E-1 | |
| 319-85-7 | hexachlor | 8080 | GC-ECD | 0.004 | | 0.0017 | - | 0.004 | 5.56E-1 | |
| 319-86-8 | hexachlor | 8080 | GC-ECD | 0.006 | | 0.0017 | - | 0.006 | | |

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|---|---|---|---|---|---|---|---|---|---|---|
| 58-89-9 | hexachlor | 8080 | GC-ECD | 0.003 | | 0.0017 | - | 0.008 | 7.69E-1 | |
| 58-89-9 | hexachlor | 8270 | GC/MS | | | | | | 7.69E-1 | |
| 77-47-4 | hexachlor | 8120 | GC-ECD | 0.27 | | 0.27 | - | 0.33 | | |
| 77-47-4 | hexachlor | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | | |
| 67-72-1 | hexachlor | 8120 | GC-ECD | 0.02 | | 0.02 | - | 0.33 | 7.14E+1 | |
| 67-72-1 | hexachlor | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | 7.14E+1 | |
| 591-78-6 | hexanone; | 8240 | GC/MS | 0.05 | | 0.001 | - | 0.05 | n/c | |
| 302-01-2 | hydrazine | 8270 | GC/MS | 1.3 | | | | | 3.33E-1 | |
| 193-39-5 | indeno[1,2 | 8270 | GC/MS | 0.66 | | 0.01 | - | 0.66 | | |
| 193-39-5 | indeno[1,2 | 8310 | HPLC | 0.029 | | 0.01 | - | 0.029 | | |
| 78-59-1 | isophoron | 8090 | GC-FID | 3.8 | | 0.33 | - | 3.8 | 1.05E+3 | |
| 78-59-1 | isophoron | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | 1.05E+3 | |
| 78-59-1 | isophorone | | GC-ECD | 11 | | | | | 1.05E+3 | |
| 7439-92-1 | lead | 6010 | ICP | 21 | | 1.25 | - | 8 | | |
| 7439-92-1 | lead | 7420 | FAA | 50 | | 0.125 | - | 0.5 | | |
| 7439-92-1 | lead | 7421 | GFAA | 0.5 | | 0.125 | - | 0.5 | | |
| 121-75-5 | malathion | 8150 | GC-FPD | #VALUE! | | | | | | |
| 7439-97-6 | mercury (i | 7470 | AA | 0.002 | | 0.125 | - | 0.5 | | |
| 7439-97-6 | mercury (i | 7471 | AA | 0.002 | | 0.1 | - | 1 | | |
| 72-43-5 | methoxych | 8080 | GC-ECD | 0.12 | | 0.0017 | - | 0.12 | | |
| 72-43-5 | methoxych | 8270 | GC/MS | | | | | | | |
| 74-83-9 | methyl bro | 9011 | GC-ECD | 0.01 | | 0.001 | - | 0.01 | | |
| 78-93-3 | methyl eth | 8015 | GC-FID | 0.1 | | 0.001 | - | 0.05 | | |
| 78-93-3 | methyl eth | 8240 | GC/MS | 0.01 | | 0.001 | - | 0.05 | | |
| 108-10-1 | methyl iso | 8015 | GC-FID | 0.1 | | 0.001 | - | 0.05 | | |
| 108-10-1 | methyl iso | 8240 | GC/MS | 0.01 | | 0.001 | - | 0.05 | | |
| 298-00-0 | methyl par | 8140 | GC-FPD | 0.02 | | 0.005 | - | 0.02 | | |
| 94-74-6 | methyl-4-c | 8150 | GC-ECD | 50 | | 5 | - | 50 | | |
| 636-21-5 | methylana | 8270 | GC/MS | 0.66 | | 0.33 | - | 0.66 | 5.56E+0 | |
| | methylana | 8270 | GC/MS | 0.66 | | 0.33 | - | 0.66 | n/c | |
| 75-09-2 | methylene | 8010 | GC-Hall | | | 0.001 | - | 0.01 | 1.33E+2 | |
| 75-09-2 | methylene | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 1.33E+2 | |
| | methylnap | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | n/c | |
| 2385-85-5 | mirex | 8270 | GC/MS | | | | | | 5.56E-1 | |
| 91-20-3 | naphthale | 8100 | GC-FID | 0.66 | | 0.05 | - | 0.66 | | |
| 91-20-3 | naphthale | 8270 | GC/MS | 0.66 | | 0.005 | - | 0.66 | | |
| 91-20-3 | naphthale | 8310 | HPLC | 1.2 | | 0.05 | - | 1.2 | | |
| vailable03 | nickel, refi | 6010 | ICP | 7.5 | | 1 | - | 4 | | |
| 7440-02-0 | nickel, sol | 7520 | FAA | 20 | | | | | | |
| 88-74-4 | nitroanilin | 8270 | GC/MS | 3.3 | | 0.1 | - | 33 | n/c | |
| 99-09-2 | nitroanilin | 8270 | GC/MS | 3.3 | | 0.1 | - | 33 | n/c | |
| 100-01-6 | nitroanilin | 8270 | GC/MS | 1.6 | | 0.1 | - | 33 | n/c | |
| 98-95-3 | nitrobenze | 8090 | GC-FID | 2.4 | | 1.7 | - | 2.4 | | |
| 98-95-3 | nitrobenze | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | | |
| 98-95-3 | nitrobenzene | | GC-ECD | 9.2 | | 0.33 | - | 9.2 | | |
| 59-87-0 | nitrofurazone | | | | | | | | 6.67E-1 | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| | nitropheno | 8040 | GC-FID | 0.3 | | | | | n/c | |
| | nitropheno | 8270 | GC/MS | 0.66 | | | | | n/c | |
| | nitrophenol;2- | | GC-ECD | 0.52 | | 0.033 | - | 0.52 | n/c | |
| | nitropheno | 8040 | GC-FID | 1.9 | | | | | n/c | |
| | nitropheno | 8270 | GC/MS | 3.3 | | | | | n/c | |
| | nitrophenol;4- | | GC-ECD | 0.47 | | | | | n/c | |
| 924-16-3 | nitroso-di- | 8070 | -Hall/GC-N | | | | | | 1.85E-1 | |
| 924-16-3 | nitroso-di- | 8250 | GC/MS | 1.3 | | 0.33 | - | 1.3 | 1.85E-1 | |
| 621-64-7 | nitroso-di- | 8070 | -Hall/GC-N | | | | | | 1.43E-1 | |
| 621-64-7 | nitroso-di- | 8250 | GC/MS | 1.3 | | 0.033 | - | 1.3 | 1.43E-1 | |
| 1116-54-7 | nitrosodie | 8070 | -Hall/GC-N | | | | | | 3.57E-1 | |
| 1116-54-7 | nitrosodie | 8270 | GC/MS | 1.3 | | 0.33 | - | 1.3 | 3.57E-1 | |
| 55-18-5 | nitrosodie | 8070 | -Hall/GC-N | | | | | | 6.67E-3 | |
| 55-18-5 | nitrosodie | 8270 | GC/MS | 1.3 | | 0.33 | - | 1.3 | 6.67E-3 | |
| 62-75-9 | nitrosodim | 8070 | -Hall/GC-N | 0.002 | | | | | 1.96E-2 | |
| 62-75-9 | nitrosodim | 8270 | GC/MS | 1.3 | | 0.33 | - | 1.3 | 1.96E-2 | |
| 86-30-6 | nitrosodip | 8070 | -Hall/GC-N | 0.008 | | | | | 2.04E+2 | |
| 86-30-6 | nitrosodip | 8270 | GC/MS | 0.66 | | 0.033 | - | 0.66 | 2.04E+2 | |
| 0595-95-6 | nitrosome | 8070 | -Hall/GC-N | | | | | | 4.55E-2 | |
| 0595-95-6 | nitrosome | 8270 | GC/MS | 1.3 | | 0.33 | - | 1.3 | 4.55E-2 | |
| 930-55-2 | nitrosopyr | 8070 | -Hall/GC-N | | | | | | 4.76E-1 | |
| 930-55-2 | nitrosopyr | 8270 | GC/MS | 1.3 | | 0.33 | - | 1.3 | 4.76E-1 | |
| 56-38-2 | parathion | 8141 | GC | 0.06 | | 0.0033 | - | 0.06 | | |
| 608-93-5 | pentachlo | 8270 | GC/MS | | | | | | | |
| 87-86-5 | pentachlo | 8040 | GC-FID | 5 | | 0.067 | - | 5 | 8.33E+0 | |
| 87-86-5 | pentachlo | 8270 | GC/MS | 3.3 | | | | | 8.33E+0 | |
| 87-86-5 | pentachlorophenol | | GC-ECD | 0.4 | | | | | 8.33E+0 | |
| 85-01-8 | phenanthr | 8270 | GC/MS | 0.66 | | 0.005 | - | 0.66 | n/c | |
| 85-01-8 | phenanthr | 8310 | HPLC | 0.43 | | 0.0083 | - | 0.43 | n/c | |
| 108-95-2 | phenol | 8040 | GC-FID | 0.094 | | | | | | |
| 108-95-2 | phenol | 8270 | GC/MS | 0.66 | | 0.1 | - | 1.5 | | |
| 108-95-2 | phenol | | GC-ECD | 1.5 | | | | | | |
| 93-65-2 | propionic | 8150 | GC-ECD | 38 | | 5 | - | 38 | | |
| 129-00-0 | pyrene | 8270 | GC/MS | 0.66 | | 0.005 | - | 0.66 | | |
| 129-00-0 | pyrene | 8310 | HPLC | 0.18 | | 0.01 | - | 0.18 | | |
| 7782-49-2 | selenium | 6010 | ICP | 0.75 | | 2.5 | - | 20 | | |
| 7782-49-2 | selenium | 7740 | GFAA | 5 | | 0.125 | - | 0.5 | | |
| 7782-49-2 | selenium | 7741 | GHAA | 1 | | | | | | |
| 7440-22-4 | silver | 6010 | | 3.5 | | | | | | |
| 7440-22-4 | silver | 7740 | | 5 | | 0.25 | - | 1 | | |
| 7440-22-4 | silver | 7741 | | 0.1 | | 0.05 | - | 0.25 | | |
| 122-34-9 | simazine | 619 | GC/NP | 0.33 | | 0.033 | - | 0.33 | 8.33E+0 | |
| 100-42-5 | styrene | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 3.33E+1 | |
| 1746-01-6 | TCDD;2,3, | 8290 | GC/MS | 0.000003 | | | | | 6.67E-6 | |
| | TCDF;2,3, | 8290 | GC/MS | 0.000003 | | | | | n/c | |
| 95-94-3 | tetrachloro | 8270 | GC/MS | 0.33 | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|
| 79-34-5 | tetrachloro | 8010 | GC-Hall | 0.0003 | | 0.0003 | - | 0.1 | 5.00E+0 | |
| 79-34-5 | tetrachloro | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 5.00E+0 | |
| 127-18-4 | tetrachloro | 8010 | GC-Hall | 0.0003 | | 0.0003 | - | 0.05 | 1.96E+1 | |
| 5216-25-1 | tetrachlorotoluene;P,a,a,a- | | | | | | | | 5.00E-2 | |
| 961-11-5 | tetrachlorv | 8141 | GC/FPD | 0.4 | | 0.005 | - | 0.4 | 4.17E+1 | |
| 108-88-3 | toluene | 8020 | GC-PID | 0.002 | | 0.001 | - | 0.025 | | |
| 108-88-3 | toluene | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | | |
| 95-80-7 | toluene-2,4-diamine | | | | | | | | 3.13E-1 | |
| 95-53-4 | toluidine;o | 8270 | GC/MS | 0.33 | | | | | 4.17E+0 | |
| 8001-35-2 | toxaphene | 8080 | GC-ECD | 0.16 | | 0.017 | - | 1 | 9.09E-1 | |
| 93-72-1 | TP;2,4,5- ( | 8150 | GC-ECD | 0.034 | | 0.01 | - | 0.1 | | |
| 120-82-1 | trichlorobe | 8120 | GC-ECD | 0.034 | | 0.034 | - | 0.33 | | |
| 120-82-1 | trichlorobe | 8270 | GC/MS | 0.66 | | 0.017 | - | 0.66 | | |
| 71-55-6 | trichloroet | 8010 | GC-Hall | 0.0003 | | 0.0003 | - | 0.05 | | |
| 71-55-6 | trichloroet | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | | |
| 79-00-5 | trichloroet | 8010 | GC-Hall | 0.0002 | | 0.0002 | - | 0.1 | 1.75E+1 | |
| 79-00-5 | trichloroet | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | 1.75E+1 | |
| 79-01-6 | trichloroet | 8010 | GC-Hall | 0.001 | | 0.001 | - | 0.01 | 9.09E+1 | |
| 75-69-4 | trichloroflu | 8010 | GC-Hall | 0.002 | | 0.001 | - | 0.025 | | |
| 75-69-4 | trichloroflu | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | | |
| 95-95-4 | trichloroph | 8270 | GC/MS | 0.66 | | 0.033 | - | 1.7 | | |
| 88-06-2 | trichloroph | 8040 | GC-FID | 0.43 | | 0.033 | - | 1.7 | 9.09E+1 | |
| 88-06-2 | trichloroph | 8270 | GC/MS | 0.66 | | | | | 9.09E+1 | |
| 88-06-2 | trichlorophenol;2,4,6 | | GC-ECD | 0.39 | | | | | 9.09E+1 | |
| 93-76-5 | trichloroph | 8150 | GC-ECD | 0.04 | | 0.01 | - | 0.2 | | |
| 512-56-1 | trimethyl p | 8270 | GC/MS | | | | | | 2.70E+1 | |
| 108-05-4 | vinyl aceta | 8240 | GC/MS | 0.05 | | 0.001 | - | 0.05 | | |
| 75-01-4 | vinyl chlor | 8010 | GC-Hall | 0.002 | | | 1 | | 5.26E-1 | |
| 75-01-4 | vinyl chlor | 8240 | GC/MS | 0.02 | | 0.001 | - | 0.01 | 5.26E-1 | |
| 1330-20-7 | xylene (tot | 8020 | GC-PID | 0.002 | | 0.001 | - | 0.04 | | |
| 1330-20-7 | xylene (tot | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | | |
| 108-38-3 | xylene;m- | 8020 | GC-PID | 0.002 | | 0.001 | - | 0.01 | | |
| 108-38-3 | xylene;m- | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | | |
| 95-47-6 | xylene;o- | 8020 | GC-PID | 0.002 | | 0.001 | - | 0.01 | | |
| 95-47-6 | xylene;o- | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | | |
| 106-42-3 | xylene;p- | 8020 | GC-PID | 0.002 | | 0.001 | - | 0.01 | n/c | |
| 106-42-3 | xylene;p- | 8240 | GC/MS | 0.005 | | 0.001 | - | 0.01 | n/c | |
| 7440-66-6 | zinc | 6010 | ICP | 1 | | 0.5 | - | 2 | | |
| 7440-66-6 | zinc | 7951 | AA | 0.03 | | | | | | |

EXHIBIT C

**Kenny, Ann**

**From:** Kmet, Peter
**Sent:** Monday, September 11, 2000 11:51 AM
**To:** Fitzpatrick, Kevin
**Subject:** RE: Clean Fill Criteria Language for the 401 Water Quality Certification on the Sea Tac Third Runway

Here are my comments. Make sure you open the attachment.

Clean Fill Criteria for 401 Ce...

----Original Message----
**From:** Fitzpatrick, Kevin
**Sent:** Friday, September 08, 2000 12:52 PM
**To:** Kmet, Peter
**Subject:** Clean Fill Criteria Language for the 401 Water Quality Certification on the Sea Tac Third Runway

**DELIBERATIVE DOCUMENT CURRENTLY EXEMPT FROM PUBLIC DISCLOSURE**

Pete: The following are additions that have been made to the 401 Certification language which are not reflected in the attached Word document below.

E6. It sounds like we are allowing the Port to use problem fill as long as the Port notify Ecology. I think the second sentence should exclude the use of inappropriate fill that may result in any potential impacts to waters of the state.

E7c.2.(b) Should include appropriate EPA databases and the first list should read as "Confirmed & Suspected Contaminated Sites Report"

E7c.2.(e) "The fill material shall be analyzed for the potential contaminant(s) identified in the environmental site assessment. At a minimum, fill material from all sites shall be analyzed for TPH and Priority Pollutants metals for compliance with MTCA method A soil cleanup levels in WAC 173-340-740." In the absence of MTCA method A soil cleanup levels, the potential contaminants shall comply with MTCA method B ~~"100 X Groundwater"~~ soil cleanup levels." [There is more to Method B than the 100 X standard. Also, we are in the process of changing that to another model and so this is no longer valid.] The sampling frequency . .

[NOTE: there are two method A cleanup tables, unrestricted and industrial soils. I'm assuming you mean unrestricted soil cleanup levels, which is why I added the reference. However, there is a problem with this language in that Method A does not have standards for all contaminants AND they are in the process of being changed. I wonder if you should instead cite natural background as the standard.]

[The reference to Method B makes no sense because Method B does not specify specific substances to analyze for. If I had to say anything here, I would say "contaminants with the potential to be in the fill material based on historical site use, available records and previous test data. For these contaminants the standard would have to be based on Method B soil cleanup levels in WAC 173-340-740. Again, there is a bit of a problem because the standards are changing.]

See if you want to add E7c.2.(f) after the sampling requirement table. This is a repeat of a sort

since the term "enviro...ental professional" is already used in a couple of places.

(f) All work shall be performed by an environmental professional, with appropriate training, experience and expertise in environmental site assessment.

E7c.3. I don't think they know where the placement location yet. The location should be included in the as-builts to be submitted quarterly.

<< File: Clean Fill Criteria for 401 Certification.doc >>

Kevin C. Fitzpatrick
Supervisor, Industrial Permit Unit
Water Quality Program, NWRO
Voice: 425-649-7037
Fax: 425-649-7098
KFIT461@ecy.wa.gov

E6. Borrow sites:

The use of fill from Port of Seattle borrow sites or other sources may result in impacts to wetlands or other waters of the state requiring additional review and approval by Ecology. The Port shall notify Ecology when the use of borrow sites on their property or from other sources may result in any potential impacts to waters of the state.

E7. Clean Fill Criteria, Certification, and Monitoring: The Port shall ensure that fill placed for the proposed project does not contain toxic materials in toxic amounts. The Port of Seattle is prohibited from using any soils or fill materials on this project that are contaminated as defined under Washington State's Model Toxics Control Act (MTCA) or any soils or fill materials which are being removed or have been treated as part of a site cleanup under MTCA, federal superfund, water quality or local health district laws. ~~were contaminated and then remediated to MTCA cleanup standards.~~ The Port shall adhere to the following conditions for fill used for this project:

E7a. Fill material shall be derived from the following sources only:

- State-certified native soil borrow pits
- Contractor-certified construction sites
- ~~Port-owned property~~

[I see no reason for distinguishing port property from any other. What does "state certified" mean? Certified by who for what purpose?]

E7b. Documentation: For materials derived from the three sources listed above, the Port and/or its contractors shall provide documentation to Ecology that a source has been certified to contain materials that are considered as clean fill. This documentation shall provide sufficient information to Ecology to evaluate whether or not the fill sources contain toxic materials in toxic amounts.

This documentation of a source's clean fill certification shall at a minimum contain the information described in E7c and shall be provided to Ecology's Water Quality Program at its Northwest Regional Office in Bellevue, WA no later than two business days prior to the acceptance of any of the source materials at a Sea-Tac International Airport construction site.

E7c. The information requirements on a source's certification shall contain at a minimum the following elements:

1. Site description with the site name and address, site plan indicating the extent of excavation, project schedule and estimated quantity of fill to be removed from the site.

2. Site investigation report which will contain at a minimum the following:

   (a) Observation of the source area and adjacent areas by an environmental professional which includes reports of any known probability of environmental impact from historical use on site or on adjacent areas.

   (b) Due diligence review of whether the source locations or adjacent areas are listed on the most current editions of the following Ecology databases:

      (1). The ~~confirmed of~~ Confirmed and suspected Contaminated Sites list;
      (2). The Underground Storage Tank listings;
      (3). The Leaking Underground Storage Tank listings.

      There is at least one other list of suspected sites maintained by EPA, the name of which escapes me.

   (c) Due diligence review of source area geologic conditions and use or operational history of the site and adjacent areas sufficient to identify potential environmental contaminants.

   (d) If no existing documentation exists for review on the site's history, then a review of site aerial photos, person or persons familiar with the site and adjacent areas and other due diligence methods will be employed to provide a site history.

   (e) At a minimum, fill material from all sites shall be analyzed for TPH and priority pollutant metals and compared with MTCA Method A cleanup standards in WAC 173-340-740. [NOTE: there are two method A cleanup tables, unrestricted and industrial soils. I'm assuming you mean unrestricted soil cleanup levels, which is why I added the reference. However, there is a problem with this language in that Method A does not have standards for all contaminants AND they are in the process of being changed.]

   Based on the site investigation and review of its operational history, an environmental professional will determine whether any additional analyses are appropriate, including but not limited to, analyses by MTCA Method B cleanup standards. [The reference to Method B makes no sense because Method B does not specify specific substances to analyze for. If I had to say anything here, I would say "contaminants with the potential to be in the fill material based on

historical site use, available records and previous test data. For these contaminants the standard would have to be based on Method B soil cleanup levels in WAC 173-340-740. Again, there is a bit of a problem because the standards are changing.]

The sampling frequency for sites where the investigation indicates no suspected contamination will be in accordance with Table 1. Sites with suspected contamination or with complex conditions will require consultation with the Department of Ecology, Water Quality Program, NWRO to determine the appropriate sampling frequency.

This sampling frequency is insufficient to determine compliance with the MTCA standards. To comply with the standards, a site must meet three requirements:
1. Upper 95% confidence limit on test results must meet standard.
2. No more than 10% of the samples can be above the standard.
3. No one sample can be more than twice the standard.

This first test requires statistical analyses. Typically, you need at least 10 samples to get the confidence limit narrow enough to pass. So, your proposed sampling schedule is not sufficient. Also, your sampling schedule is not likely to find contamination. I think the biggest problem is construction sites, not borrow pits. So the below comments reflect this.

I suggest you go with something more like the one in our petroleum contaminated soil guidance for construction sites and port owned property. This acknowleges:

| VOLUME OF SOIL (cubic yards) | MINIMUM NUMBER OF SAMPLES |
|---|---|
| 0-100 | 3 |
| 101-500 | 5 |
| 501-1000 | 7 |
| 1001-2000 | 10 |
| >2000 | 10 plus 1 for each additional 500 cy. |

For native soil borrow pits (which should be clean and also much bigger) I recommend you start with a minimum of 10 samples and go up from there, something like this:

| VOLUME OF SOIL (cubic yards) | MINIMUM NUMBER OF SAMPLES |
|---|---|
| <50,000 | 10 |
| 50,001 – 500,000 | 15 |

| | |
|---|---|
| >500,000 | 15 plus 1 for each additional 100,000 CY |

| VOLUME OF SOIL (cubic yards) | MINIMUM NUMBER OF SAMPLES |
|---|---|
| <1,000 | 2 |
| 1,000 – 10,000 | 3 |
| 10,000 – 50,000 | 4 |
| 50,000 – 100,000 | 5 |
| >100,000 | 6 |

3. Every source certification will list the initial placement of fill location and its grade elevation. The Port of Seattle will also provide quarterly summaries of each certified source of fill which lists the certified sources employed in that quarter, quantities of fill material from those sources, and the locations and elevation grades for the placement of those fill sources on Port of Seattle property.

Additional conditions or corrective actions may be required based on Ecology's review of the documentation.

E7d. Any changes to the criteria or process described in the above conditions is subject to review and written approval by Ecology.