APPENDIX A

ECOLOGICAL SURVEY OF THE INDUSTRIALIZED PORTION OF THE FORMER RAYONIER MILL SITE, PORT ANGELES, WASHINGTON

This page intentionally left blank.

APPENDIX A

ECOLOGICAL SURVEY OF THE INDUSTRIALIZED PORTION OF THE FORMER RAYONIER MILL SITE, PORT ANGELES, WASHINGTON

1. INTRODUCTION

The industrialized portion of the former Rayonier Mill Site is under consideration for inclusion into a quantitative ecological risk assessment as part of the remedial investigation/feasibility study for the uplands environment. Under the Washington Model Toxics Control Act (MTCA), the goal of the terrestrial ecological evaluation for industrialized portions of industrial sites is the protection of wildlife species. MTCA recommends evaluating risks to wildlife using food chain models for indicator wildlife species that include the shrew (insectivorous mammal), American robin (insectivorous bird), and the vole (herbivorous mammal). As described in the Uplands RI/FS Work Plan, the ecological risk assessment will use food chain models for these indicator wildlife species and site-specific information to assess ecological risks on the industrialized portion of the site. The primary route of exposure of these indicator species is through the ingestion of biota that bioaccumulate contaminants from the soil. MTCA states that if the wildlife exposure pathway is incomplete, no further evaluation is necessary. The objectives of this survey are to characterize the potential for wildlife to become exposed to soil-borne chemicals on the industrialized portion of the site and to characterize the presence of plants and soil invertebrates that are the food base for wildlife.

2. COVER SURVEY

The soil cover present on the industrialized portion of the former Rayonier Mill Site was characterized using aerial photographs and a site reconnaissance. The soil cover was classified into one of five types:

- Open Ground – areas not covered by pavement, concrete, or mounded concrete rubble; substrate ranged from crushed concrete to native soil
- Pavement/Slab-on-Grade – areas paved with asphalt or covered with concrete slab-on-grade laid directly on top fill or soil

- Concrete Rubble over Pavement/Slab-on-Grade – concrete rubble from mill dismantling mounded to a height of 6 inches to 7 feet and placed over asphalt pavement or concrete slab-on-grade
- Concrete Rubble over Open Ground - concrete rubble from mill dismantling mounded to a height of 6 inches to 7 feet and placed over open ground
- Elevated Slab – concrete slabs elevated on concrete pilings; substrate is heterogeneous fill material

Results of the survey are shown in Figure A-1.

Wildlife may become exposed to soil-borne chemicals in areas with open ground, concrete rubble over open ground, and an elevated slab. It is assumed that the concrete rubble may be removed at some point exposing the paved/slab on grade areas or open ground that occur beneath the rubble. Wildlife exposure is incomplete in areas with pavement/slab-on-grade or areas with concrete rubble over pavement/slab-on-grade and these areas will be excluded from further ecological evaluation.

3. SOIL INVERTEBRATE AND PLANT SURVEY

The industrialized portion of the former Rayonier Mill Site that provides a potentially complete exposure pathway for wildlife was the subject of further ecological evaluation. Since one of the main pathways of wildlife exposure to soil-borne chemicals is ingestion of prey that has accumulated chemicals form the soil, an understanding of the prey distribution on the site is important information for refining the ecological risk assessment. This information is also useful for designing the sampling and analysis plan.

MTCA describes the primary food sources for the indicator wildlife species to be earthworms for the shrew and robin, and vegetation (primarily grasses) for the vole. The distribution of earthworms on the industrialized portion of site is expected to be more limited than grasses because earthworms occupy a more limited set of ecological niches.

This survey consists of a review of the environmental requirements of earthworms and describes the methodology and results of the qualitative plant and earthworm survey conducted on the industrialized portion of the site.

3.1 ENVIRONMENTAL REQUIREMENTS OF EARTHWORMS

Earthworms are found in all but the driest and coldest land areas of the world and have a significant effect upon the soil which they inhabit (Lee 1985; Satchell 1983).

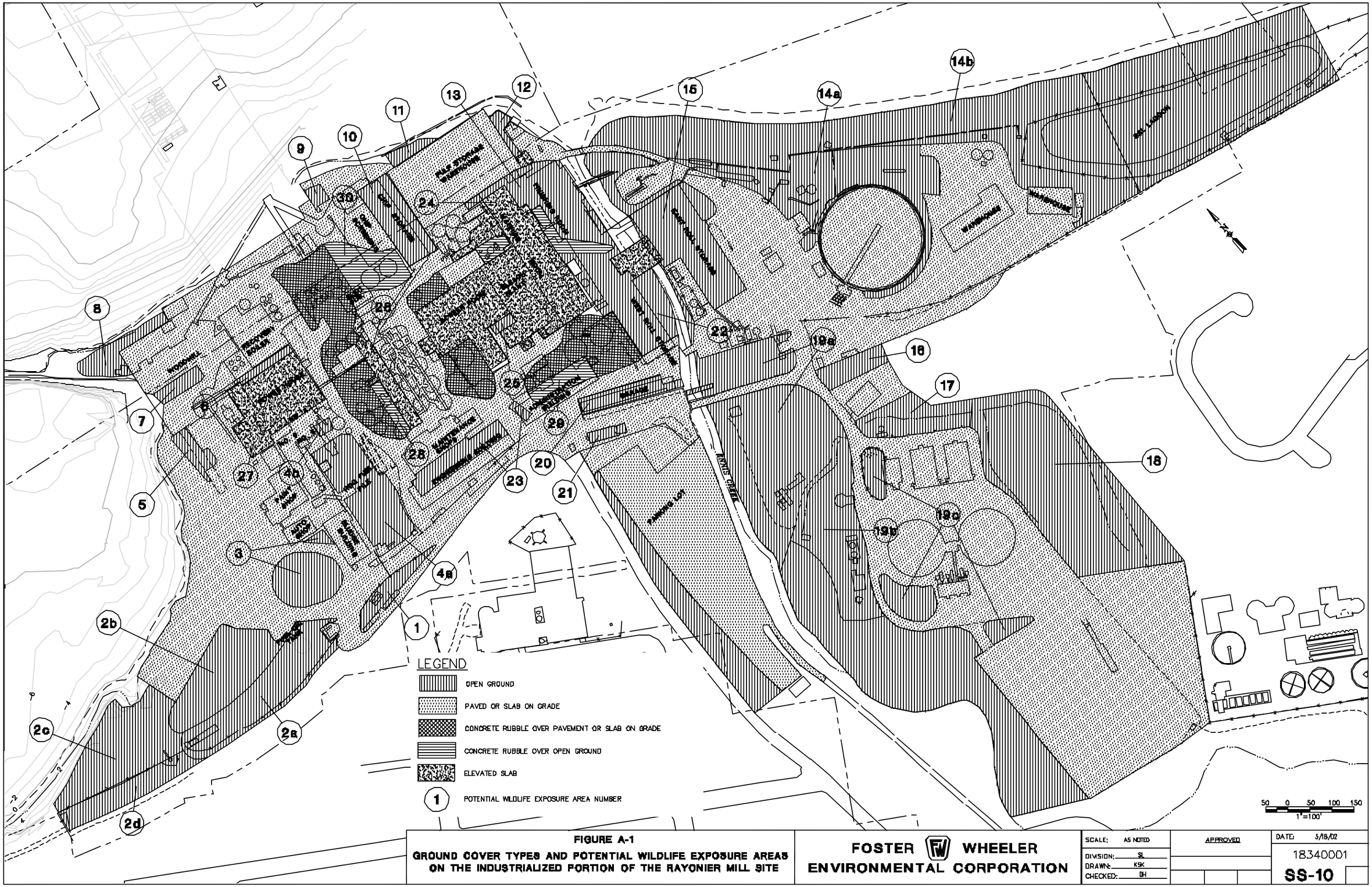

FIGURE A-1
GROUND COVER TYPES AND POTENTIAL WILDLIFE EXPOSURE AREAS ON THE INDUSTRIALIZED PORTION OF THE RAYONIER MILL SITE

FOSTER WHEELER ENVIRONMENTAL CORPORATION

SCALE: AS NOTED
DIVISION: SL
DRAWN: KSK
CHECKED: DH
APPROVED
DATE: 3/18/02
18340001
SS-10

L:\PROJECTS\18340001\DWG\ERAYBL2-PACK.DWG
PLOT/UPDATE: JAN 23 2003 11:28:34

Earthworms have basic environmental requirements that include adequate and suitable food supplies, adequate moisture, suitable temperature, adequate respiratory exchange, protection from light, suitable soil texture, and suitable pH and electrolyte concentrations (Lee 1985). Variation in these physical and chemical characteristics controls the presence, abundance, and diversity of earthworm populations in soils.

The industrialized portion of the former Rayonier Mill Site was historically an alluvial beach deposit created at the mouth of Ennis Creek. Fill was placed on the site to create a base for the industrial development. The site was used as a pulp mill from 1930 until it was decommissioned in 1997. Although much of the surface of the industrialized portion of the site is covered by concrete and asphalt, areas with open ground exist that could provide habitat for earthworms. Several factors can prohibit the establishment of earthworm populations on open areas at the site, the most pertinent being food supply, soil texture/moisture, and bulk soil density.

3.1.1 Food Supply

An adequate and suitable food supply is a basic environmental requirement of earthworms (Lee 1985). Although earthworms are known to feed on dung, fungi, microorganisms, and nematodes, their primary food in decaying plant matter. Some species of earthworms feed at the soil surface on decomposing plant litter (detritivores), while other species feed deeper beneath the surface, ingesting large quantities of soil, selecting portions higher in organic matter (geophages). A minimum quantity and quality of organic material is required to maintain viable earthworm populations. Hendrix et al. (1992) studied the effect of ecosystem types, management practices, landscape position, soil textures and soil erosion status on the abundance and distribution of earthworm populations in the Georgia Piedmont. They found that earthworm density dropped from over 500 worms/m^2 in soil with greater than 2% organic carbon to 0 worms/m^2 when organic carbon fell below 0.75%.

Many of the open areas on the industrialized portion of the mill site (e.g., Bone Yard, Administration Building) have little vegetative cover with a substrate of coarse sandy gravel. The organic matter content of these areas has not been measured, but appears to be very low. These areas are not expected to provide sufficient organic matter to support earthworm populations. Several areas (e.g., Chip Storage, East and West Roll Storage) have a fairly dense vegetative cover where the organic matter content should be relatively high. These areas could potentially support earthworm populations.

3.1.2 Soil Texture

A suitable soil texture is another basic environmental requirement of earthworms (Lee 1985). Earthworms are absent or rare from soils with very coarse texture. The abrasiveness of coarse textured soil and their susceptibility to drought limit species composition and abundance of earthworms. Hendrix et al. (1992) studied the effect of

ecosystem types, management practices, landscape position, soil textures and soil erosion status on the abundance and distribution of earthworm populations in the Georgia Piedmont. They found that earthworm density dropped from 255 - 301 worms/m^2 in finer textured soils (55-65% sand:10-20% clay:25% silt) to 60 worms/m^2 in soil with relatively coarse texture (80% sand:15% clay:5% silt).

Many of the open areas on the industrialized portion of the site (e.g., Bone Yard, Administration Building) appear to have a substrate of coarse sandy gravel. These areas are not expected to provide a soil environment conducive to supporting earthworm populations. Several areas of the site (e.g., Chip Storage, East and West Roll Storage) contain substrate augmented by organic matter inputs (e.g., wood chip, plant litter) that have modified the soil texture and increased water-holding capacity. These areas could potentially support earthworm populations.

3.1.3 Soil Compaction

Earthworms move through soil by mechanical locomotion (i.e., elongating their bodies into pore spaces and then expanding their bodies to push the soil particles sideways to form a burrow) and if insufficient pore space is available, by engulfing soil particles and excreting them as casts (Lee 1985). Compacting the soil increases bulk density, decreases gas exchange through decrease in pore space, and decreases water holding capacity and percolation. Highly compacted soils can significantly inhibit earthworm movement. For example, Sochtig and Larnik (1992) investigated the effect of three levels of soil compaction associated with standard machinery use on agricultural soils. Earthworm abundance was reduced from 51.5 to 22.1 earthworms/m^2 and earthworm biomass was reduced from 19.1 to 9.5 g/m^2 when the bulk density of the soil was increased from 1.32 g/cm^3 under control conditions to 1.52 g/cm^3 under the heaviest level of machine use. Similarly, Pizl (1992) investigated the affect of heavy machinery and extensive vehicular traffic on the abundance and biomass of earthworms in three apple orchards. Soil and earthworm samples were collected from trafficked and untrafficked areas in each orchard. The soil bulk density was higher in the trafficked area of each orchard, while the earthworm density and biomass were lower in the trafficked area of each orchard (Table A-1).

Table A-1. Soil and Earthworm Properties Trafficed and Untrafficked Areas in Three Apple Orchards.

Characteristic	Orchard 1		Orchard 2		Orchard 3	
	Untrafficked	Trafficked	Untrafficked	Trafficked	Untrafficked	Trafficked
Soil Bulk Density (g/cm^3)	1.45	1.78	1.59	1.81	1.22	1.47
Earthworm Density (individuals/m^2)	369.1	146.1	243.2	163.2	129.1	30.9
Earthworm Biomass (g/m^2)	53.3	21.2	37.9	31.0	21.6	6.8

The industrialized portion of the former Rayonier Mill Site was under heavy industrial use for more then 60 years. During decommissioning, heavy equipment (e.g., cranes, caterpillar tractors) was used to dismantle buildings and equipment, crush concrete, and level the site. The historic use of the property and recent decommissioning activities has probably left a highly compacted and coarse substrate on many of the remaining open areas. Although no measurement of the compactness of the soil at the site has been made, it appears that many open areas are highly compacted. These areas would not be conducive to the establishment of earthworm populations.

3.2 QUALITATIVE SURVEY OF EARTHWORMS AND PLANTS

A qualitative survey of the density of earthworms and plants present in open areas within the industrialized portion of the former Rayonier Mill Site was conducted in the spring of 2002 when soil moisture and temperature conditions were conducive for maintaining healthy earthworm populations. Open areas were surveyed during a site visit conducted on April 10, 2002. Several additional areas were surveyed on April 15, 2002.

3.2.1 Methodology

All areas with open ground and one accessible area covered with a concrete slab on pilings were visited during the qualitative site survey. The survey consisted of the following activities:

- Vegetative cover in each area was characterized as absent, sparse, moderate, or dense
- Dominant plant cover types were noted as grasses, forbs, shrubs, and/or trees (species were noted where possible)
- Substrate was excavated with a shovel and the following characteristics noted:
  - Organic matter content – low, moderate or high determined visually by color (i.e., light = low OM, dark = high OM); the presence of wood chips was noted
  - Texture – fine-grained, sand, and/or gravel determined visually
  - Compactness – compacted or not compacted determined by the ease of penetration of the substrate with a shovel
- Earthworm density was determined by hand-sorting substrate samples excavated by shovel to a depth of approximately 10 to 20 cm; earthworm density was noted as absent, few, or many; the number of soil samples evaluated from each area ranged from 1 to 5 depending upon the size of the area, homogeneity of soil characteristics, soil texture, and soil compactness (e.g., earthworms were unable to burrow into highly compacted soil, so a single sample from an area with homogeneous soil conditions was sufficient to confirm the absence of earthworms)

Photographs were taken of most areas.

An ecologist made a subjective determination as to whether vegetation (stems and leaves of grasses) and/or earthworms could be effectively collected from each area. This determination was made by evaluating the size of the area and the density of suitable grass and earthworm populations.

Weather in Port Angeles during and immediately preceding surveys was obtained online (www.wunderground.com) and summarized as follows:

- April 9 - cloudy, light rain, temperature range 43 to 52° F
- April 10 - partly cloudy, light rain, temperature range 45 to 54° F
- April 14 - cloudy, rain, temperature range 37 to 48° F
- April 15 - cloudy, light rain, temperature range 36 to 48° F

3.2.2 Results

Areas providing potential exposure of wildlife to soil-borne chemicals were identified and numbered as shown on Figure 1. Survey results are summarized in Table 2.

3.2.3 Conclusions

Much of the industrialized portion of the site is covered by concrete on grade or asphalt, which prevents wildlife from becoming exposed to soil-borne chemicals. The remaining areas contain open ground that can be broadly categorized into five groups:

- **Open Ground Areas Consisting of Compacted Sandy Gravel (i.e., 1, 2b, 2c, 3, 4a, 4b, 5, 6,18, 19a, 21, 23)** – These areas provide poor habitat for the establishment of plant and earthworm populations. They have lain fallow since decommissioning and some have been Hydroseeded (WDOT mixture of seed and recycled paper). Nonetheless, they currently contain little or no vegetation. If present, vegetation is limited to noxious grasses/forbs. The compacted nature of the substrate, low fertility and limited water holding capacity inhibit plant establishment. Earthworms are absent from these areas because of compaction, seasonally dry conditions, and lack of food.
- **Open Ground Areas Consisting of Uncompacted Sandy Gravel (i.e., 2a, 2d, 7, 8, 9, 11, 12, 13, 14a+b, 16, 17, 19b+c, 20, 25)** – These areas have presumably been subject to less industrial use and therefore have less compacted soil. Vegetative cover ranges from sparse to moderate, organic matter content is generally higher, and earthworms may or may not be present. The presence of earthworms is likely limited by substrate conditions and the migration potential of earthworms.

- **Open Ground Areas Previously Covered by Structures on Pilings (i.e., 10, 15, 22)** - The substrate is sandy gravel that is not compacted. The low spots are inundated for part or all of the year producing anoxic soil conditions. They have a dense vegetative cover and earthworms are present in spots with greater drainage. Plants apparently rapidly colonized these areas. Earthworms migrated into these areas from nearby refugia.
- **Areas Currently Covered by Concrete Slabs on Pilings (i.e., 24, 26, 27)** – The substrate in Area 24 is composed of sandy gravel and is not compacted. Wood pulp deposits occur in localized areas. Substrate was dry and plants and earthworms were absent. It is assumed that conditions are similar in Area 26 and 27 were inaccessible at the time of the survey, but conditions similar to those at Area 24 are assumed be present.
- **Open Ground Areas Covered by Concrete Rubble (i.e., 28, 29, 30)** – These areas were inaccessible at the time of the survey. However, considering the depth of concrete rubble, it is assumed that neither earthworms nor plants are present.

This page intentionally left blank.

Table A-2. Summary of Survey (Part 1 of 5)

Area	**Substrate Characteristics**	**Vegetation Characteristics**	**Earthworm Presence**	**Photograph**	**Biota Sampling Potential**
1 (in front of site office)	Sandy gravel, low OM, compacted	Sparse low grass/forb cover (dandelions)	Few	1 and 2	Vegetation – no Earthworms - no
2a (Log Yard – SE wet area)	Moderately fine-grained, moderate OM, not compacted	Moderately dense grass/forb cover in more elevated area (reed canary grass); cattails and alder in wet area	Many	3	Vegetation – yes Earthworms - yes
2b (Log Yard – N area)	Sandy gravel, low OM, compacted	Sparse low grass cover [Note: area previously Hydroseeded with WDOT mixture]	Absent	4	Vegetation – no Earthworms - no
2c (Log Yard – W area)	Sandy gravel, low OM, compacted	Sparse low grass/forb cover [Note: area previously Hydroseeded with WDOT mixture]	Absent	None	Vegetation – no Earthworms – no
2d (Log Yard – W area bordering gravel road)	Sandy gravel, moderate OM, not compacted	Moderately dense grass/forb cover (dandelions) [Note: area previously Hydroseeded with WDOT mixture]	Few	None	Vegetation – yes Earthworms – no/yes
3 (Fuel Tank #2 & small area to NE)	Sandy gravel, low OM, compacted; small drainage in southern portion with moderate texture and OM	Sparse grass/forb cover (dandelion, mustard, horsetail); drainage has moderately dense cover	Absent; few in drainage	5	Vegetation – yes Earthworms - no
4a (Hog Fuel Pile)	Recently excavated, standing water, but currently pumped (Note: area backfilled with crushed concrete following 2002 Interim Action)	None	Standing water precluded earthworm presence	None	Vegetation – no Earthworms - no
4b (N of Hog Fuel Pile)	Sandy gravel, low OM, compacted	None	None	None	Vegetation – no Earthworms - no
5 (W of Power House)	Sandy gravel, low OM, compacted;	Sparse forb cover	Absent	6	Vegetation – no Earthworms - no
6 (N of Power House)	Sandy gravel, low OM, compacted; old road bed	None	None	7	Vegetation – no Earthworms - no

Table A-2. Summary of Survey (Part 2 of 5)

Area	Substrate Characteristics	Vegetation Characteristics	Earthworm Presence	Photograph	Biota Sampling Potential
7 (NW of Power House)	Sandy gravel, low OM, compacted	Moderate forb/grass cover	None	8	Vegetation – no/yes Earthworms - no
8 (Breakwater)	Sandy gravel, low OM, compacted; extreme east and west portions have less compacted soil with higher OM	Sparse grass/forb cover; east and west portions of area have moderate forb/grass cover	None	9	Vegetation – no/yes Earthworms – no
9 (E of base of dock)	Sandy gravel, moderate OM, not compacted	Moderate grass/forb cover	None	10	Vegetation – yes Earthworms – no
10 (Chip Storage Area)	Area previously excavated; soil in elevated areas along margins are sandy gravel with wood chips, high OM, not compacted; lower area inundated and anoxic	Moderate grass/forb cover	Few	11 and 12	Vegetation – yes Earthworms – no/yes
11 (NE of Chip Storage Area)	Sand and wood chips	Dense grass/forb cover, some shrubs (willow and alder)	None	13 and 14	Vegetation – yes Earthworms – no
12 (N of Finishing Room)	Sand and wood chips	Dense grass/forb cover, some shrubs (blackberry and elderberry)	None	15	Vegetation – yes Earthworms – no
13 (N and NE of Machine Room)	Low wet area, sandy gravel, moderate OM, not compacted	Moderate grass/forb cover, some shrubs (blackberry and elderberry)	None	16	Vegetation – yes Earthworms - no
14a (NW of Primary Clarifier)	Sandy gravel, moderate OM, not compacted	Moderate grass/forb cover (thistle), some shrubs (blackberry and elderberry)	None	17 and 18	Vegetation – yes Earthworms - no
14b (Shoreline N of Primary Clarifier)	Sandy to sandy gravel, low to moderate OM, compacted	Moderate grass/forb cover (dandelions)	Few (near buildings)	None	Vegetation – yes Earthworms - no

Table A-2. Summary of Survey (Part 3 of 5)

Area	Substrate Characteristics	Vegetation Characteristics	Earthworm Presence	Photograph	Biota Sampling Potential
15 (East Roll Storage)	Lower areas are sandy gravel, high OM, not compacted, poorly drained and anoxic; localized slightly elevated areas have improved drainage/aeration	Dense grass/forb cover (dandelions, rushes, sedges)	None in low areas; few in elevated areas	19 and 20	Vegetation – yes Earthworms – no/yes
16 (S of Primary Clarifier)	Sand and pea gravel, moderate OM, not compacted	Moderate grass/forb cover (dandelion, horsetail)	None	21	Vegetation – yes Earthworms - no
17 (Drainage Ditch NW of Bone Yard)	Sand and pea gravel; moderate OM, not compacted	Dense grass/forb cover (thistle, mustard)	Few	22	Vegetation – yes Earthworms – no/yes
18 (Bone Yard)	Sandy gravel, low OM, compacted; ditch along eastern border has moderate OM and not compacted	Sparse grass/forb cover; moderate grass/forb cover along ditch	None; few along ditch	23 and 24	Vegetation – no Earthworms – no [Note: vegetation and earthworm sampling may be possible along E ditch]
19a (Pre-fab Area and Chlorine Dioxide Generator)	Sandy gravel, low OM, compacted; west border along Ennis Creek has moderate OM and not compacted	Sparse grass/forb cover; moderate grass/forb cover along Ennis Creek	None	None	Vegetation – no Earthworms - no
19b (S of Pre-fab Area)	Sandy gravel, low OM (some wood chips present), compacted	Sparse grass/forb cover (dandelions)	Few	None	Vegetation – yes Earthworms – no/yes
19c (N+S of Water Storage Tank)	Sandy gravel, low OM, not compacted	Sparse grass/forb cover (dandelions)	Few	None	Vegetation – yes Earthworms – no/yes

Table A-2. Summary of Survey (Part 4 of 5)

Area	Substrate Characteristics	Vegetation Characteristics	Earthworm Presence	Photograph	Biota Sampling Potential
20 (Garage Area)	Southern area is sandy gravel, moderate OM, not compacted; northern area is sandy gravel, low OM, compacted	Souther area has moderate grass/forb cover with shrubs (alder and planted birch; northern area has sparse grass/forb cover	Few; none in N portion	25	Vegetation – yes Earthworms – no/yes
21 (S of Parking Lot)	Sandy gravel, low OM, compacted	Sparse grass/forb cover	None	None	Vegetation – no Earthworms - no
22 (West Roll Storage)	Lower areas are sandy gravel, high OM, not compacted, poorly drained and anoxic; localized elevated areas have improved drainage/aeration	Dense grass/forb cover (dandelions, rushes, sedges)	None in low areas; few in elevated areas	26	Vegetation – yes Earthworms – no/yes
23 (Engineering Building & small area to E)	Sandy gravel, low OM, compacted (Note: area backfilled with crushed concrete following 2002 Interim Action)	Sparse grass/forb cover (Note: none in area of 2002 Interim Action)	None	27	Vegetation – no Earthworms - no
24 (under elevated concrete slab NE corner of Machine Room/Bleach Plant)	Areas of wood pulp intermixed with sandy gravel, not compacted	None	None	28	Vegetation – no Earthworms - no
25 (Bleach Plant/Screen Room)	Sandy gravel, low OM, not compacted (low area inundated anoxic conditions present)	None	None	None	Vegetation – no Earthworms - no
26 (under elevated concrete slab N of Maintenance Shop)	[Note: this area was inaccessible at the time of the survey, but because of the enclosed nature of the area and the nature of area #24, it can be assumed that no earthworms or plants are present]				

Table A-2. Summary of Survey (Part 5 of 5)

Area	Substrate Characteristics	Vegetation Characteristics	Earthworm Presence	Photograph	Biota Sampling Potential
27 (under elevated concrete slab for Power House)	[Note: this area was inaccessible at the time of the survey, but because of the enclosed nature of the area and the nature of area #24, it can be assumed that no earthworms or plants are present]				
28 (under 3' of concrete rubble N of maintenance Shop	[Note: this area was inaccessible at the time of the survey, but because it is covered with concrete rubble it is assumed that no earthworms or plants are present]				
29 (under 6"-7' of concrete rubble at the W side of Administration Building)	[Note: this area was inaccessible at the time of the survey, but because it is covered with concrete rubble it is assumed that no earthworms or plants are present]				
30 (under 7' – 11' of concrete rubble at the Chip Screening building)	[Note: this area was inaccessible at the time of the survey, but because it is covered with concrete rubble it is assumed that no earthworms or plants are present]				

This page intentionally left blank.

4. REFERENCES

Hendrix, P.F., B.R. Mueller, R.R. Bruce, G.W. Langdale, and R.W. Parmelee. 1992. Abundance and distribution of earthworms in relation to landscape factors on the Georgia Piedmont, U.S.A., Soil Biology & Biochemistry 24 (12): 1357-1361.

Lee, K.E. 1985. Earthworms: Their Ecology and Relationships with Soil and Land Use. Academic Press, New York, New York. 411 pp.

Pizl, V. 1992. Effect of soil compaction on earthworms (Lumbricidae) in apple orchard soil. Soil Biology & Biochemistry 24 (12): 1573-1575.

Satchell, J.E. (ed.). 1983. Earthworm Ecology: From Darwin to Vermiculite. Chapman and Hall, New York, New York. 496 pp.

Sochtig, W. and O. Larink. 1992. Effect of soil compaction on activity and biomass of endogeic lumbricids in arable soils. Soil Biology & Biochemistry 24 (12): 1595-1599.

This page intentionally left blank.