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South River and South Fork of the Shenandoah River Natural Resource Damage Assessment

Damage Assessment Plan

18 MAY 2011

prepared for:

United States Department of the Interior,
Fish and Wildlife Service

Commonwealth of Virginia,
Department of Environmental Quality

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EXECUTIVE SUMMARY

From 1929 to 1950 mercury was released to the South River from the former DuPont Waynesboro Facility ("the Facility"). Over time, released mercury has been transported downstream to the South Fork of the Shenandoah River and the Shenandoah River, and flooding has deposited mercury on the floodplains associated with these river reaches. Mercury is a toxic pollutant and exposure to mercury can have adverse effects on biota (e.g., reduced reproductive success in birds). Sampling has determined that mercury concentrations in biota are elevated compared to background levels.

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the United States Department of the Interior (DOI) and the Commonwealth of Virginia are Trustees for natural resources potentially injured by the release of mercury from the Facility. As Trustees, they have the authority to assess potential hazardous substance related injuries to natural resources and seek appropriate compensation for those injuries. The process through which the Trustees evaluate injuries and determine appropriate compensation is called "natural resource damage assessment" (NRDA). The goal of the NRDA is to restore injured resources to their but-for release condition and to compensate the public for losses pending achievement of that restoration. As allowed for under DOI's regulations for the conduct of a NRDA, this assessment is being conducted cooperatively with the responsible party, E.I. du Pont de Nemours and Company (DuPont).

One step in the NRDA process is the development of a Damage Assessment Plan (Plan). This Plan serves to ensure that the NRDA is conducted in an efficient and cost effective manner, and describes the Trustees' proposed approach to determining injury and appropriate compensation. In this document, the Trustees outline their proposed approach to the injury determination, injury quantification, and damage determination phases of the assessment.

During the NRDA process, the Trustees will produce and release for public comment several key documents, including this Plan. The Trustees encourage active participation of the public in the assessment through the public comment process.

LIST OF ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CoC	contaminants of concern
CWA	Clean Water Act
DOI	U.S. Department of the Interior
DuPont	E.I. DuPont de Nemours and Company
EPA	Environmental Protection Agency
the Facility	INVISTA (formerly DuPont) facility
FEMA	Federal Emergency Management Agency
FTL	Field Team Leader
FWS	U.S. Fish and Wildlife Service
HEA	Habitat Equivalency Analysis
LAT	Lead Administrative Trustee
NCP	National Contingency Plan
NRDC	Natural Resource Defense Council
NRDA	natural resource damage assessment
PI	principal investigator
Plan	Damage Assessment Plan
PPM	parts per million
QA	quality assurance
QAP	Quality Assurance Plan
QC	quality control
RCDP	Restoration and Compensation Determination Plan
REA	Resource Equivalency Analysis
SDWA	Safe Drinking Water Act
SFSR	South Fork of the Shenandoah River
SOPs	standard operating procedures
SRST	South River Science Team
Trustees	U.S. Department of the Interior U.S. Fish and Wildlife Service and Virginia Department of Environmental Quality
VDEQ	Virginia Department of Environmental Quality
WQC	water quality criteria

CHAPTER 1 | INTRODUCTION

The South River is located in Augusta County in the western portion of Virginia. From its headwaters southwest of the town of Waynesboro, Virginia, the South River flows in a northerly direction to the town of Port Republic. At this point, the South River merges with the North River to form the South Fork of the Shenandoah River (SFSR). From Port Republic, the SFSR continues flowing in a northerly direction to the town of Front Royal where it merges with the North Fork of the Shenandoah and forms the Shenandoah River proper. To the southeast of the watershed are the Blue Ridge Mountains and to the northeast are rolling hills (Eggleston 2009). The area surrounding the South River and the SFSR is mostly forested and agricultural land, interspersed with small urban populations including the Towns of Waynesboro, Grottoes, and Elkton.

Waynesboro, Virginia is located approximately 24 miles upstream of where the South River and North River merge. From 1929 to 1950 a textile plant in Waynesboro used mercury as a catalyst in the production of synthetic fibers. During this time, mercury was released from the plant to the South River and has since been transported and re-circulated downstream via surface water, sediments, and floodplain soils to the SFSR and eventually to the Shenandoah River. Mercury contamination in the South River and South Fork Shenandoah River was identified in the 1970s. Sampling initiated in the late 1970s, and continuing today, has confirmed that mercury concentrations in sediment, surface water, ground water, soil, and wildlife are elevated compared to background levels. Although mercury use ceased in 1950, mercury releases from the former plant site continue to this day.

In 2007 the Commonwealth of Virginia Department of Environmental Quality (VDEQ), together with the U.S. Department of the Interior (DOI) acting through the U.S. Fish and Wildlife Service (FWS), determined that it was appropriate to undertake a natural resource damage assessment (NRDA) of the South River, South Fork Shenandoah River, and adjacent habitats. VDEQ and FWS are currently conducting this NRDA under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for the South River, South Fork Shenandoah River, and adjacent habitats. This NRDA will evaluate natural resource injuries and corresponding damages resulting from releases of hazardous substances from the INVISTA (formerly DuPont) Facility (the Facility). Elements of this assessment are being conducted cooperatively with E.I. du Pont de Nemours and Company (DuPont). In addition, DuPont has completed and is currently undertaking site-specific studies to determine the extent and effects of mercury exposure in collaboration with the South River Science Team (SRST) and the Natural Resource Defense Council (NRDC; NRDC 2005).

One of the primary steps in a NRDA is the development of a Damage Assessment Plan (Plan). The purpose of this Plan is to:

> *ensure that the [damage] assessment is performed in a planned and systematic manner and that methodologies…including the Injury Determination, Quantification, and Damage Determination phases, can be conducted at a reasonable cost (43 C.F.R. § 11.30(b)).*

This Plan describes the Trustees' approach to the damage assessment, summarizing existing data as well as completed, ongoing, and proposed studies that have been or will be used to evaluate Facility-related contamination and its effects on natural resources and resource services. It is envisioned that the assessment process will be iterative, thus this Plan will be revised as additional information becomes available. The remainder of this Chapter discusses the role and approach to coordination of the Trustees, the intent to perform a "Type B" assessment, cooperation with the responsible party, public participation, public review and comment, the assessment timeline, and the Plan's organization.

ROLE AND COORDINATION OF THE TRUSTEES

Under Federal law, the Trustees are authorized to act on behalf of the public to assess and recover natural resource damages, and to plan and implement actions to restore, replace, or rehabilitate natural resources injured or lost as a result of the release of a hazardous substance, and/or to acquire the equivalent resources (42 U.S.C. §9601 et seq. (CERCLA); 43 C.F.R. §11).[1] The natural resource Trustees for this matter are DOI, represented by the FWS, and the Commonwealth of Virginia, represented by VDEQ. Pursuant to the CFR Title 43 § 11.32(a)(1), the FWS is acting as the "Lead Administrative Trustee (LAT)."[2]

The objective of a NRDA and the ultimate goal of the Trustees is to restore natural resources that have been injured by a hazardous substance(s) to baseline, which is defined as the condition of the resource that would have existed if the hazardous substances were not released[3], and obtain compensation for public losses pending restoration to baseline condition.

INTENT TO PERFORM A TYPE B ASSESSMENT

As part of the assessment planning process, the Trustees must decide to conduct a simplified assessment ("Type A") or a comprehensive assessment ("Type B"). The Type A procedures, which use minimal field observations in conjunction with computer models to generate a damage claim, are limited by the regulations to the assessment of relatively minor, short duration discharges or releases in coastal or marine environments or in the

[1] Collectively referred to as "restoration."

[2] The LAT act as coordinator and contact regarding all aspects of the assessment.

[3] Baseline is "the condition that would have existed at the assessment area had the…release of the hazardous substance…not occurred" (43 CFR § 11.4(e)). For more information regarding baseline conditions see Chapter 4.

Great Lakes. Type B procedures allow for a range of alternative scientific and economic methodologies to be used for Injury Determination, Quantification and Damage Determination. Based on the Trustees' determination that: (1) the release did not occur in a coastal, marine, or Great Lakes habitat, (2) the nature of the release and resource exposure to mercury are long-term and spatially and temporally complex, (3) substantial site-specific data already exist to support the assessment, and (4) additional site-specific data can be collected at reasonable cost, the Trustees have concluded that the use of Type B procedures is appropriate. As such, in accordance with the NRDA regulations the Trustees have confirmed that at least one of the natural resources identified as potentially injured has in fact been exposed to the released hazardous substance and a Quality Assurance Plan has been prepared (Appendix A).[4]

COOPERATION WITH THE RESPONSIBLE PARTY

Under CERCLA, the parties responsible for releases of hazardous substances may be invited to participate cooperatively in the NRDA and restoration planning process (43 C.F.R. §11.32(a)(2)). Cooperative assessments can act to reduce duplication of effort, expedite the assessment, and accomplish resource restoration earlier than might otherwise be the case. However, the final authority regarding determinations of injury and restoration rests with the Trustees.

For this NRDA, the Trustees have identified DuPont as the party responsible for releases of hazardous substances and corresponding natural resource damages, and have invited DuPont to participate in a cooperative assessment for the site. The Trustees have entered into a cooperative funding agreement between the Trustees and DuPont, designed to provide a framework for cooperative NRDA activities. To-date, DuPont's involvement in the damage assessment process includes providing funding and assistance for assessment activities, providing site-specific and other technical information, maintaining a database of contaminant concentration data, and participating in the development of injury assessments for ecological and human use services.

PUBLIC PARTICIPATION

The Trustees intend to coordinate with the general public throughout this NRDA and encourage active public participation. Public participation is a required component of the Plan's development process. Specifically:

> *The authorized official must make the Assessment Plan available for review by any identified potentially responsible parties, other natural resource trustees, other affected Federal or State agencies or Indian tribes, and any other interested member of the public for a period of at least 30 calendar days, with reasonable extensions granted as appropriate. The authorized official may not*

[4] Mercury concentrations in the edible portions of 84 percent of bass collected in 1977 from within the assessment area exceeded Federal guidelines for the maximum allowable concentration of mercury in fish (The Free Lance Star 1977).

perform any type B procedures described in the Assessment Plan until after this review period (43 C.F.R. § 11.32(c)(1)).

The Trustees and DuPont are collaboratively carrying out and developing resource-specific studies to better understand system specific mercury fate and transport. As ongoing studies are completed they will be reviewed by the Trustees and incorporated into the NRDA. As such, this Plan may be modified at any stage of the assessment as new information becomes available and as specific study plans are developed (43 C.F.R. § 11.32(e)). Significant modifications (e.g., resource-specific study plan amendments) or additions to this Plan will also be made available for review by any interested public party or individual, and will be appended to this Plan. For more information regarding completed, ongoing, planned, and proposed site-specific studies see Chapter Three.

Public Review and Comment

The Trustees encourage active participation of the public in this damage assessment. A notice of availability of the draft Plan was published in the *News Virginian* on March 31, 2011, and a public comment period ended on April 29, 2011. Copies of this Plan were made available to the public at the City of Waynesboro Public Library, 600 South Wayne Avenue, Waynesboro, Virginia 22980, and online at the following Federal and State Websites:

http://www.fws.gov/northeast/virginiafield/contaminants/NRDAR.html

http://www.deq.virginia.gov/fishtissue/mercury.html

The U.S. Fish and Wildlife Service, acting as LAT, is the central contact point for the Trustee Council. Copies of the Plan and other information were also available through written request from:

Anne Condon
U.S. Fish and Wildlife Service
Virginia Field Office
6669 Short Lane
Gloucester, Virginia 23061

The Trustees received no comment letters from public entities.

PLAN ORGANIZATION

This Plan provides relevant background information and describes the Trustees' approach to the three major steps in the assessment process: 1) injury determination, including pathway determination, 2) injury quantification, and 3) damage determination and restoration. This NRDA framework is consistent with the DOI regulations (43 CFR § 11.00) and provides an effective means of considering the impacts of Facility-related mercury contamination. Within each of these steps, the Trustees will undertake individual studies that will define the nature and extent of injuries caused by Facility-

related mercury contamination in the assessment area as well as the required scale of restoration efforts. The remainder of this document contains the following chapters:

- **Background Information (Chapter 2):** This chapter provides an overview of the South River, including a brief discussion of the industrial and remedial activities that have occurred at the Site; lists contaminants of concern (CoCs); describes potentially impacted natural resources and the services they provide; and establishes the temporal and geographic scope of the assessment.
- **Injury Determination (Chapter 3):** This chapter describes likely pathways and completed, ongoing, and planned investigations to determine injuries to natural resources resulting from exposure to Facility-related mercury.
- **Injury Quantification Phase (Chapter 4):** This chapter describes the Trustees technical approach for determining the quantity of loss (e.g., as measured by a change in resource services) sustained by each injured resource across space and time.
- **Damage Determination Phase (Chapter 5):** This chapter provides a brief overview of the approach the Trustees currently anticipate following to calculate damages.

CHAPTER 2 | BACKGROUND INFORMATION

The former DuPont Waynesboro Facility is located on DuPont Boulevard on the eastern shore of the South River in Waynesboro, Virginia. The Facility covers approximately 177 acres and is located in an industrial area of Waynesboro (US Environmental Protection Agency (EPA) 2008). DuPont began operations at the Facility in 1929, manufacturing acetate flake and yarn, collectively referred to as acetate fibers. In 1958, DuPont added the manufacturing of Orlon® to their operations (US EPA 2008). These two processes were discontinued in 1977 and 1990, respectively. Production of Lycra®, Permasep®, and BCF Nylon began in 1962, 1969, and 1978, respectively (US EPA 2008). In 2004 the Facility was sold to INVISTA, a subsidiary of Koch Industries, Incorporated; the plant has the capability of producing Lycra and BCF Nylon, but currently only Lycra is produced (US EPA 2008). From 1929 to 1950, mercury, used as a catalyst during manufacturing processes, was discharged to adjacent soil and surface waters of the South River and, ultimately, releases from soil impacted groundwater. As a result, a variety of natural resources have been exposed to Facility-related mercury.

The remainder of this chapter outlines the natural resources found within the assessment area, the services those resources provide, the hazardous substance of principal concern (mercury), the geographic scope of the assessment, and the temporal scope of the assessment.

NATURAL RESOURCES AND THE SERVICES THEY PROVIDE

Pursuant to 43 CFR § 11.14(z), natural resources are defined as:

> *land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States…any State or local government…These natural resources have been categorized into the following five groups: surface water resources, groundwater resources, air resources, geologic resources, and biological resources.*

This Plan and the assessment focus on biological resources and human uses of those resources in two habitat types: riverine and floodplain. The riverine habitat includes the area within the banks of the South River and the SFSR; the floodplain includes the area adjacent to the river within the 100-year floodplain as defined by the Federal Emergency Management Agency. Within the riverine habitat the invertebrate community consists of over 100 distinct taxa (DuPont 2009) that support anywhere from 13 to 25 warm water

fish species (DuPont 2009) depending on the microhabitat (e.g., riffle or pool).[5] Other organisms that rely on aquatic invertebrates as prey include birds, reptiles, amphibians (Hopkins 2006, Cristol 2008); and multiple small mammals, including six species of bats and possibly the American water shrew, a State endangered species (Biodiversity Research Institute 2007). The invertivorous fish community is in turn preyed upon by piscivores, such as smallmouth bass, belted kingfishers, herons, and otters. The floodplain habitat supports a wide array of species as well, including an invertebrate community (e.g., spiders, beetles, moths, and crickets), approximately 30 species of breeding songbirds, and several species of small mammals (Biodiversity Research Institute 2007, Cristol 2008). Additionally, larger fauna, such as deer, foxes, owls, and black rat snakes, utilize the floodplain habitat.

Specific examples of biota found within the assessment area include:

- *Invertebrates* (aquatic and terrestrial) such as crayfish, mollusks, mayflies, crickets, spiders, and moths;
- *Fish*, such as smallmouth bass, largemouth bass, sunfish, suckers, and forage fish;
- *Birds*, such as belted kingfishers, eastern phoebe, eastern bluebirds, screech owls, American robin, Carolina wrens, and house wrens;
- *Amphibian*s, such as American toads, two-lined salamanders, and red-back salamanders;
- *Reptiles*, such as red-bellied turtles, painted turtles, stinkpots, snapping turtles, and black rat snakes; and
- *Mammals*, such as shrews, muskrats, mink, otters, northern long-eared bat, big brown bat, eastern pipistrelle, eastern red bat, and little brown bat.

ECOLOGICAL SERVICES

Each of these natural resources provides a variety of ecological services. For example, rivers provide habitat for numerous aquatic plant and animal species. Riverbank communities provide protective cover, spawning, and nursery habitat for aquatic biota, aid in nutrient cycling, maintain hydraulic flows, and improve water clarity by promoting sedimentation of particulate matter. Phytoplankton and zooplankton serve as prey for aquatic invertebrates and help to cycle nutrients in aquatic habitats. Fish, amphibians, and reptiles help to control insect populations and serve as prey for higher trophic level organisms, such as birds and mammals. Floodplain habitat provides nesting and denning habitat for a suite of species, as well as flood control during storm events.

HUMAN USE SERVICES

Human use services provided by the South River and SFSR include recreational opportunities such as fishing and boating, as well as use of adjacent parks and shoreline

[5] A riffle is a shallow area of a stream in which water flows rapidly over a rocky or gravelly stream bed and a pool is a deeper, smoothly flowing section of river.

for activities that include walking, jogging, bicycling, bird and wildlife viewing, and duck hunting.

HAZARDOUS SUBSTANCE RELEASES

From 1929 to approximately 1950, DuPont used mercury as a catalyst in the manufacturing process for acetate fibers at the Facility, resulting in the release of mercury as part of the industrial waste stream. Although the industrial waste was heated to separate the mercury for reuse, this process was not completely efficient, and un-captured mercury was discharged into the South River.

In 1976, elemental mercury was encountered in soil during construction activities relating to a water line at the Facility. In April of 1977, DuPont notified the Commonwealth of Virginia and the Federal Government of possible mercury contamination (The Free Lance Star 1977). Later that year, Virginia's Department of Health closed 130 miles of the South River and SFSR to fishing because mercury concentrations in the edible portions of fish exceeded Federal guidelines for mercury contamination (The Free Lance Star 1977, US EPA 2009).

A subsequent sediment survey, conducted in 1977-1978, confirmed the presence of mercury in streambed sediments downstream of the Facility at levels as high as 76 parts per million (ppm; Stahl 2001). Elemental mercury continues to be encountered during site investigations at the Facility and mercury releases to the South River continue to occur via storm water runoff (Liberati 2008a, 2008b). Current remedial activities are focused on identifying the source of elemental mercury. Under the direction of the US EPA, DuPont has initiated investigations to identify sources of mercury at the Facility, focusing on the Facility outfalls and sewer system.

MERCURY AND METHYLMERCURY

Mercury is considered to be the primary contaminant of concern for this assessment, and is listed in Table 302.4, the List of Hazardous Substances and Reportable Quantities under CERCLA, and as a toxic pollutant pursuant to 40 CFR 401.15, as amended.

As mercury cycles through the environment, it can be present in several different forms. "Quicksilver," or mercury-zero, is metallic, elemental mercury (such as the mercury released from the Facility), and is less toxic than other forms. Elemental mercury is converted to methylmercury, the most common, and most toxic, organic mercury compound, mainly by microscopic organisms in water, soil, and sediment. Methylmercury is lipid soluble, allowing it to cross biological membranes and to enter the food web, where it is bioaccumulated and biomagnified in upper trophic level organisms (e.g., fish and birds).[6,7]

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[6] Bioaccumulation refers to the net accumulation of a contaminant within an individual from all sources and occurs when the rate of intake is greater than the rate of elimination. Biomagnification refers to the increase in concentration of a contaminant from one trophic level to the next due to contamination of food.

[7] See Chapter 3 for more information on bioaccumulation, biomagnifications, and food web pathways.

Mercury is primarily a neurotoxin, but can also cause biochemical, enzymatic, immunological, genetic, and reproductive effects on biota. For example, in adult mammals, methylmercury can cause ataxia (i.e., inability to coordinate muscle movements), difficulty in locomotion, impairment of hearing or vision, general weakness, and death (Eaton et al. 1980, Wren et al. 1987a and 1987b). Symptoms of acute mercury poisoning in birds include, but are not limited to, reduced food intake leading to weight loss; progressive weakening in wings and legs; difficulty flying, walking and standing; and death (Wolfe et al. 1998). Reductions in egg laying and territorial fidelity also were associated with mercury exposure in birds (Barr 1986).

GEOGRAPHIC SCOPE OF THE ASSESSMENT

The assessment area is defined in the DOI regulations as

> *the area or areas within which natural resources have been affected directly or indirectly by the discharge of oil or release of a hazardous substance and that serves as the geographic basis for the injury assessment* (43 CFR § 11.14(c)).

For the purposes of this Plan, Exhibit 2-1 depicts the preliminary geographic scope of the assessment area, which includes, but may not be limited to:

- The South River from just upstream of the Facility in Waynesboro downstream to Port Republic, Virginia.
- The South Fork of the Shenandoah River from Port Republic downstream to Front Royal, Virginia.
- Floodplain areas adjacent to the South River and South Fork of the Shenandoah River where mercury has come to be located.

TEMPORAL SCOPE OF THE ASSESSMENT

The temporal scope of this assessment is based on the determination of injury to natural resources and corresponding damages. According to the DOI regulations, injury has occurred when there is:

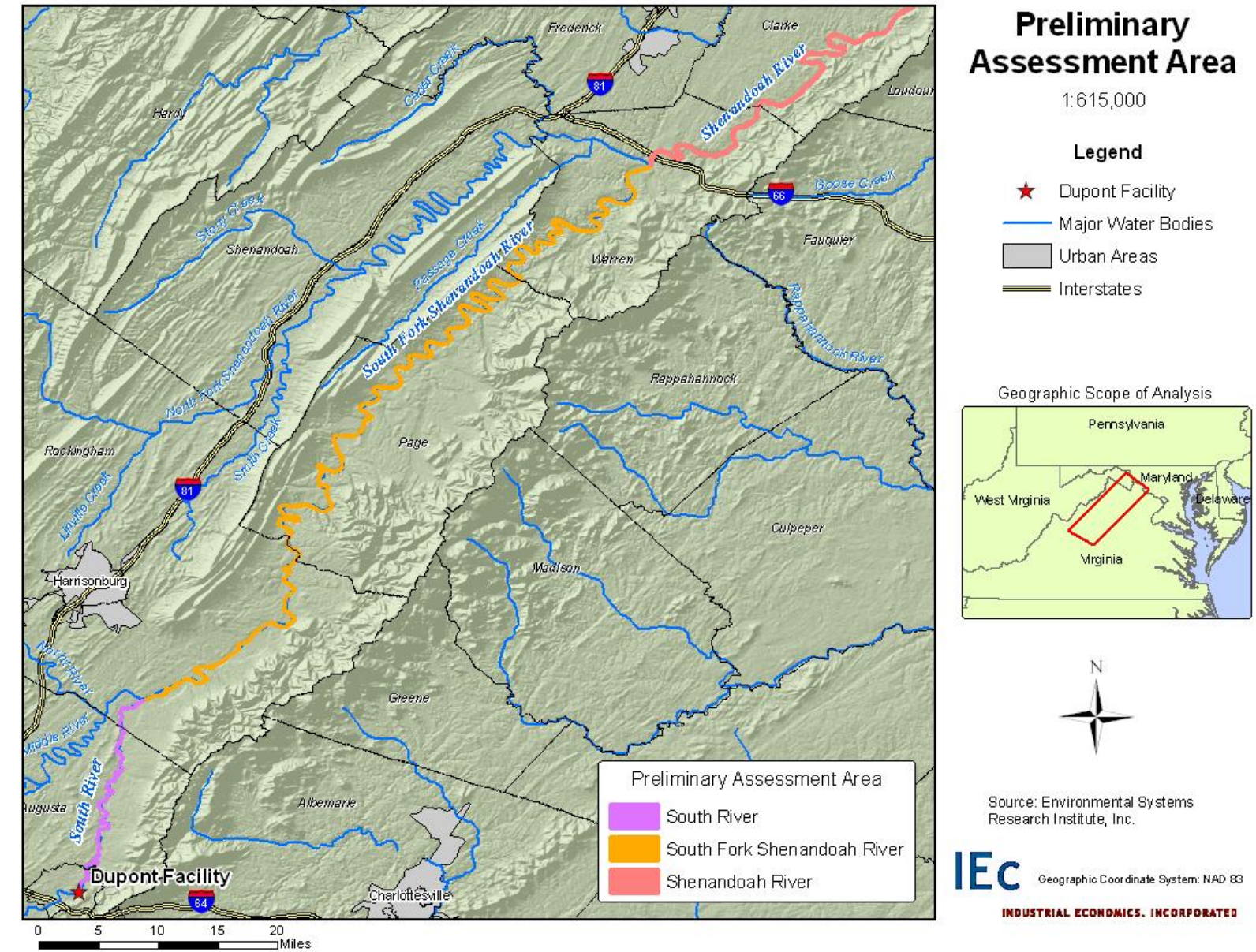
> *A measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a…release of a hazardous substance* (43 CFR § 11.14(v)).

Within the assessment area, natural resources have likely been exposed to mercury since approximately 1929 and exposure is expected to continue into the future. This is based on the industrial history of the Facility and the physical and chemical properties of the mercury within the proposed assessment area.

For this assessment the goal of the Trustees will be to determine the appropriate scale of restoration as compensation for injury to natural resources. Damages are calculated beginning in December of 1980, in accordance with the promulgation of CERCLA and continuing through the reasonable expected recovery of resource services. The rate of

recovery will be based upon proposed or implemented remedial/restoration activities, natural attenuation, and expected resource recoverability.

EXHIBIT 2-1 THE PRELIMINARY ASSESSMENT AREA



CHAPTER 3 | INJURY DETERMINATION

Natural resources within the assessment area have been and continue to be adversely affected by both historical releases and the continuing release of mercury to the South River and SFSR. To determine injuries to natural resources exposed to Facility-related mercury, the Trustees will be guided by the injury definition provided in the DOI NRDAR regulations at 43 CFR § 11.14(v), together with the specific criteria set forth in the DOI NRDA regulations (43 CFR § 11.62). The remainder of this chapter addresses pathways and injury to natural resources.

PATHWAY

Pursuant to 43 CFR § 11.14(dd), a pathway is defined as:

> *The route or medium through which…a hazardous substance is or was transported from the source of the discharge or release to the injured resource.*

During the pathway determination phase, the Trustees will document how mercury moves through the environment and which natural resources are potentially exposed to Facility-related mercury. Specifically, the movement of mercury from the source (the Facility) to the environment and into the food web will be determined. The pathway determination phase will also establish how mercury moves from one species to another.

To date, Facility-related mercury has been identified in storm water runoff originating from outfalls at the Facility (South River Science Team 2007) and several higher trophic species (e.g., snapping turtles and screech owls; Cristol 2006, Hopkins 2006). Although site-specific investigations have described numerous abiotic and biotic pathways uncertainty still exists (e.g., terrestrial food web pathways). For example, individual species of birds, which presumably feed at the same trophic level, exhibit different mercury exposure patterns (Cristol 2006). As such, pathway studies within the assessment area are ongoing (Newman and Tom 2008, Eggleston 2009, Newman et al. 2009) and future studies will build upon existing information. Additional details regarding pathways studies are described in the following sections.

PRIMARY PATHWAYS

The primary, ongoing pathways from the point of release, the Facility, to Trust resources include, but may not be limited to, storm water runoff from the Facility to the South River and infiltration and discharge to surface water via groundwater. Evidence for these pathways can be found in the fact that mercury is regularly detected in storm water runoff and in groundwater in the vicinity of the Facility. Investigations to determine the source of mercury at the Facility are ongoing (Liberati 2008a, 2008b). After its release from the Facility, mercury can be transported via movement in surface water and by both abiotic and biotic pathways as described below.

Abiotic Pathways: Surface Water, Sediment, and Floodplain Soils

Once elemental mercury has been released to surface water, including sediments, it can be transported downstream via surface water flow. During periods of flooding, mercury can be deposited on floodplain soils (e.g., when heavy rains cause the South River and SFSR to overtop their banks). Furthermore, contaminated floodplain soils in this study area can be transported back into the river via bank erosion processes (Eggleston 2009). Mercury in sediment and floodplain soils can be taken up by biota at the base of the food web and transported to higher trophic organisms via their diet. As such, aquatic and terrestrial biota may also serve as pathways in addition to being endpoints. The flow chart presented in Exhibit 3-1 depicts known and potential pathways.

Biotic Pathways: The Food Web

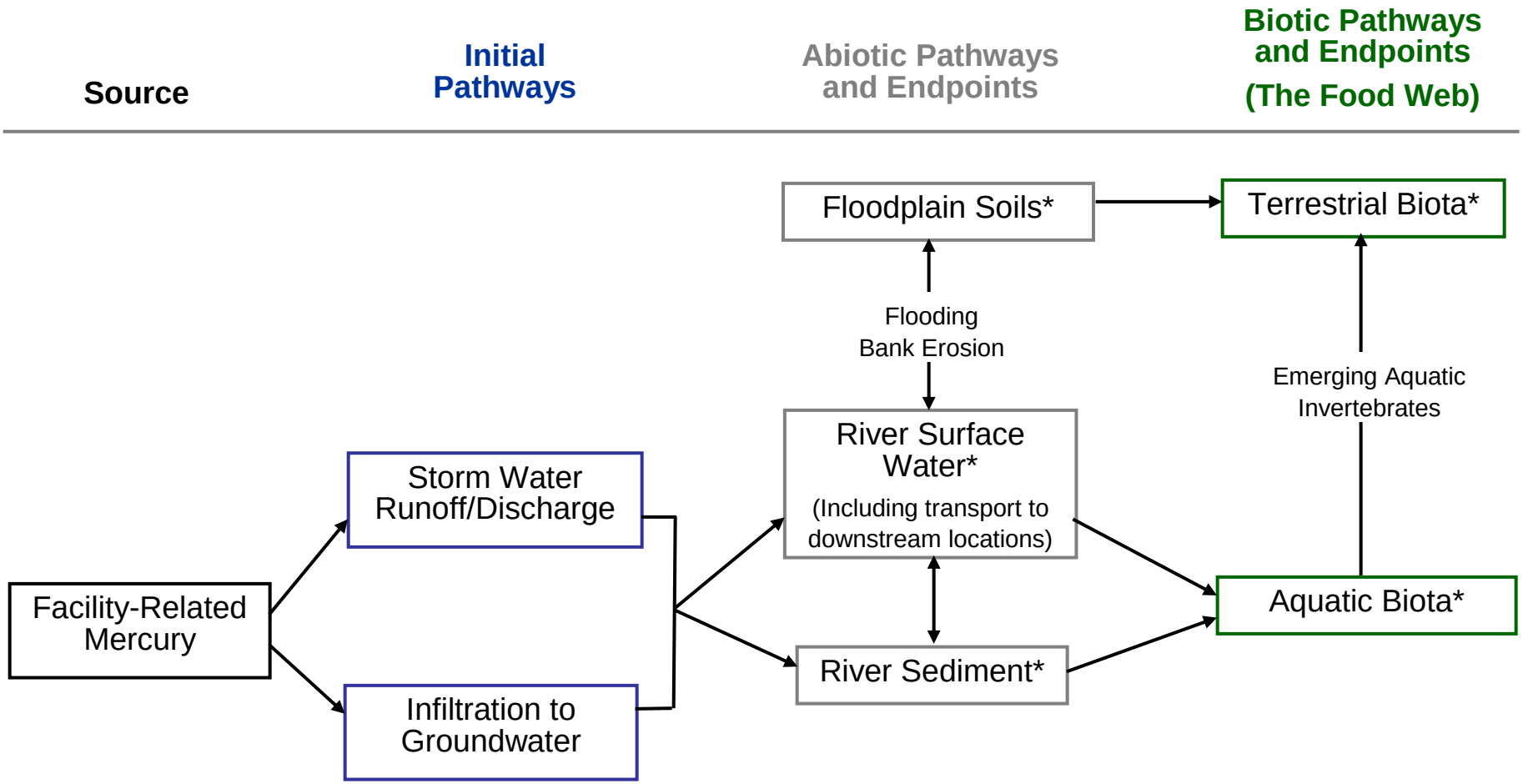
From abiotic resources (e.g., sediment), mercury, specifically methylmercury, can enter the base of the food web where it readily bioaccumulates and biomagnifies in biota. Bioaccumulation likely begins in river sediment and periphyton, where elemental mercury is methylated.[8,9] Organic matter in sediment and periphyton are important food sources for aquatic invertebrates, which form the base of the aquatic food web. Previous studies have established that Facility-related mercury is present in sediment, periphyton, and aquatic invertebrates of the South River and SFSR (Stahl 2001, Newman and Tom 2006). Once methylmercury bioaccumulates in aquatic invertebrates it can biomagnify to higher trophic organisms such as fish-eating birds and mammals.

In the floodplain, soil and detritus likely play a similar role to sediment and periphyton. However, it is important to note that the aquatic and floodplain food webs are not separate entities but intertwined systems -- many organisms utilize both the aquatic and terrestrial environment (e.g., tree swallows). A multiyear study to describe the movement of mercury within the food web is ongoing. Exhibit 3-2 is a food web in the assessment area (reproduced from DuPont 2008).

[8] Periphyton is algae and bacteria attached to submerged surfaces.

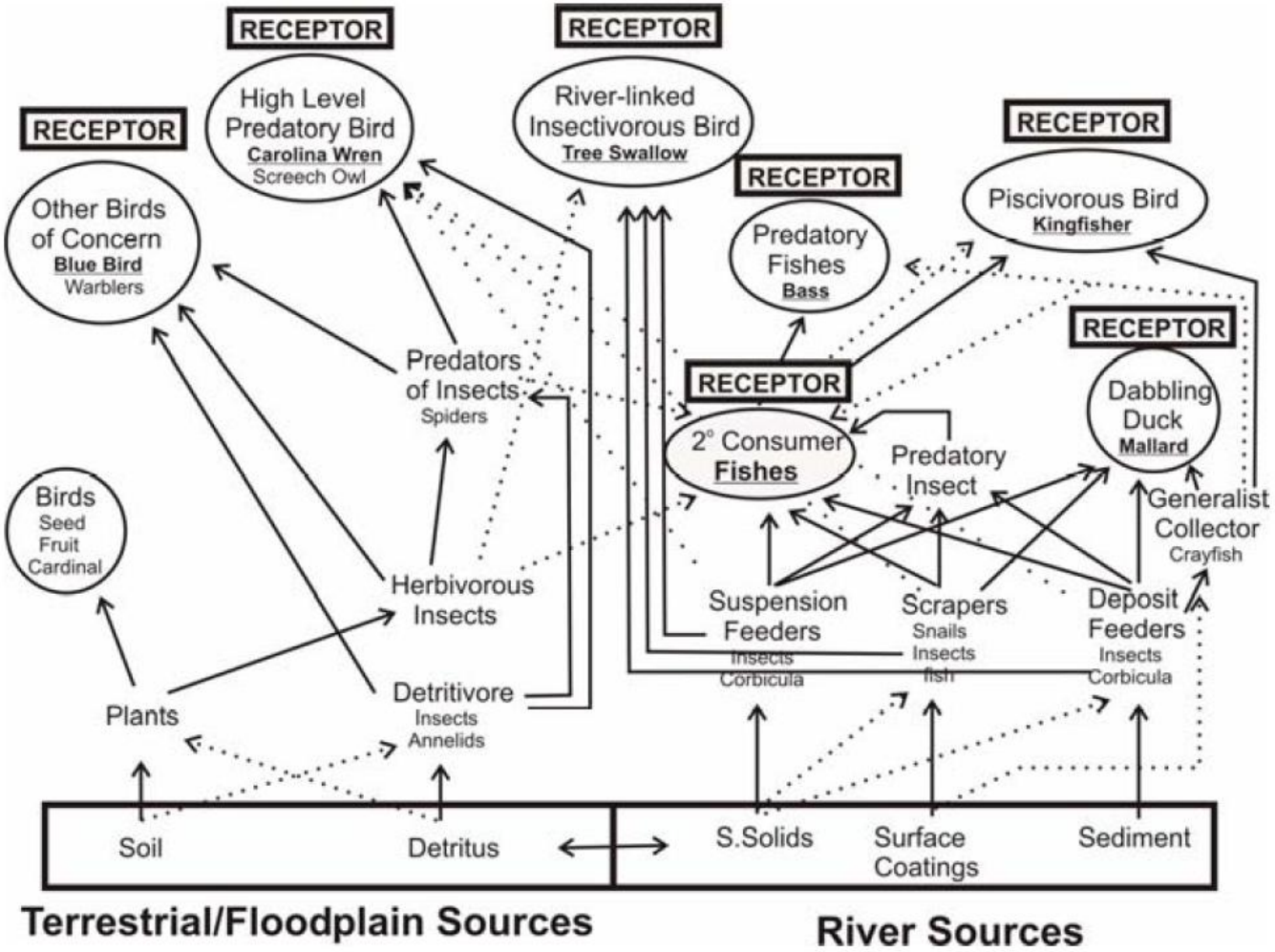
[9] Elemental mercury is primarily methylated by bacteria.

EXHIBIT 3-1 KNOWN AND POTENTIAL PATHWAYS



* Indicates a Trust resource being assessed in the NRDA process.

EXHIBIT 3-2 SOUTH RIVER AND SFSR FOOD WEB (REPRODUCED FROM DUPONT 2008)



The intermeshed trophic webs leading to relevant fish and bird receptors. These diverse receptors include fish feeding on aquatic macroinvertebrates or other fish (bass), dabbling ducks feeding heavily on aquatic scrapers (mallard), piscivirous birds (belted kingfisher), insectivorous birds feeding over water (tree swallow), predatory birds feeding mostly, but not solely, on terrestrial prey (screech owl), and insectivorous birds feeding predominately on terrestrial prey (Carolina and house wrens and eastern bluebird). Solid and dashed lines indicate major and minor pathways, respectively (Newman as provided by DuPont 2008).

INJURY TO TRUST NATURAL RESOURCES

As described in Chapter 2, Trust resources within the assessment area include, but are not limited to, surface water, sediment, soil, and biota. Injuries to Trust resources, as defined in the DOI NRDA regulations, generally fall into two categories. The first establishes injury based on the exceedence of regulatory standards or criteria (Exhibit 3-3). This may include exceedence of established standards or the existence of advisories limiting/banning the consumption of contaminated biota. The second category establishes injury based on adverse changes in an organism's viability. Injury, according to the DOI regulations, is explained in more detail in the following sections.

Where injury can not be demonstrated as a result of an exceedence of standards, multiple options exist to establish and prove injury, including, but not limited to, performing site-specific laboratory toxicity studies (e.g., Adams and Rowland 2003). Exhibit 3-4 presents representative injury studies, including those which have been or may be undertaken to further evaluate injury to surface water within the assessment area.

The Trustees have identified a set of natural resources found within the assessment area on which to focus the NRDA. Resources were chosen based on their relative and/or cumulative importance to the healthy functioning of the ecosystem, abundance within the assessment area, and the feasibility of conducting mercury exposure and/or toxicity studies on each resource. As described in the following sections, at this time the Trustees are evaluating potential injury to surface water, sediments, floodplain soils, and various biota associated with these resources. This list of resources may be modified as assessment activities proceed and additional information becomes available.

For each selected resource, the Trustees will gather existing information about past, present, and predicted future concentrations of mercury and compare these data to baseline information when appropriate or known criteria, standards, guidance values, or other thresholds that, if exceeded, indicate that injury to the resource exists or is likely to exist. In addition, site-specific community structure and toxicity studies have been completed or are ongoing for biota that have focused on macroinvertebrate, fish, avian, and the herpetological communities (Exhibit 3-4). The Trustees will review these studies in the context of the NRDA and use the findings to inform whether injury has occurred or is likely to occur in any portion of the study area.

As part of this effort, the Trustees will assess whether sufficient data exist to adequately characterize injury to Trust resources. As described in the preceding sections, pathway studies have determined that mercury can be transported downstream via surface water flow and mercury can be transported through a complex food web. Although considerable effort has been undertaken to describe mercury exposure across many resources, for some resources the available data are limited. For example, spatial data downstream of the town of Port Republic, Virginia may be insufficient to characterize the downstream extent of mercury contamination in the floodplain. As such, the Trustees may decide to conduct additional studies. Such studies may include, but are not limited to, floodplain soil investigations and songbird exposure studies.

SURFACE WATER

Aquatic organisms are at risk of mercury exposure through their diet, as well as through direct contact with metals in the water column. Although concentrations of mercury dissolved in surface water tend to be low compared to concentrations in sediments, prolonged exposure to relatively low concentrations can lead to or add to the accumulation of mercury in the food web.

Under the DOI regulations, injury to surface water from the release of a hazardous substance has occurred when concentrations and duration of substances are:

> *(i) In excess of drinking water standards as established by…[the] SDWA [Safe Drinking Water Act], or by other Federal or State laws or regulations,…in surface water that was potable before…the release;*
>
> *(ii) In excess of water quality criteria established by…[the] SDWA, or by other Federal or State laws or regulations…in surface water that before…the discharge or release met the criteria and is a committed use…as a public water supply; or*
>
> *(iii) In excess of applicable water quality criteria established by…the CWA [Clean Water Act], or by other Federal or State laws or regulations…in surface water that before the…release met the criteria and is a committed use…as a habitat for aquatic life, water supply, or recreation* (43 C.F.R. § 11.62 (b)(1)).

Note that "*the most stringent criterion shall apply when surface water is used for more than one of these purposes*" (43 C.F.R. § 11.62 (b)(1)(iii)).

To evaluate the potential for ecological injury due to elevated mercury levels in surface water of the assessment area, dissolved mercury concentrations in surface water can be compared to chronic (770 nanograms per liter (ng/l)) and acute (1,400 ng/l) criteria for mercury based on the Aquatic Life Water Quality Criteria (WQC) promulgated by the US EPA (Exhibit 3-3).[10] The WQC promulgated by the EPA for mercury are equivalent to those promulgated by the Commonwealth of Virginia and are the most stringent criteria associated with the assessment area.

Between 1981 and 2008, surface water samples were collected from a variety of locations within the assessment area under both base and storm flow conditions and analyzed for mercury. The Trustees analyzed surface water data by year and flow condition for the South River and SFSR. Five samples in this analysis exceeded both the acute and chronic criteria promulgated by the EPA. These exceedences represent less than ten percent of the total samples collected in the corresponding year. As such, the Trustees have concluded that although surface water in the South River and SFSR has been injured under the DOI regulations, this injury likely will not be a focus of this assessment effort.

SEDIMENT

Benthic flora may be exposed to mercury through direct uptake and contact and fauna may be exposed to mercury through their diet as well as through direct contact with

[10] ng/l is equivalent to parts per trillion.

mercury in sediments. Sediment communities are integral to maintaining the structure and function of the aquatic ecosystem (e.g., function as the base of the aquatic food web), and play an important role in ecosystem energy and nutrient cycling.

Injury to sediment is defined as a component of injury to surface water resources, and has occurred when:

> *concentrations and duration of substances [are] sufficient to have caused injury…to ground water, air, geologic, or biological resources, when exposed to surface water, suspended sediments, or bed, bank, or shoreline sediments*" (43 CFR § 11.62(b)(1)(v)).

To evaluate the potential for ecological injury due to mercury concentrations in the sediment, the Trustees are conducting a preliminary analysis of the results of sediment sampling performed in the area between 2005 and 2008. Area weighted sediment mercury concentrations are being compared to the 50 and 95 percent toxicity threshold (0.49 ppm and 6.93 ppm, respectively) presented by Field et al. (2002; Exhibit 3-3). Exceedence of this threshold would indicate that injury is likely.[11] A preliminary analysis of sediment samples collected downstream of the Facility but upstream of the town of Port Republic, Virginia indicate that the mercury concentrations in 83 percent of sediment exceeded the 95 percent toxicity threshold.[12] As such, the Trustees have concluded that injury to sediment is likely.

Analysis of injury to sediment is ongoing. To further investigate injury to this resource, the Trustees' proposed approach is to divide the assessment area into segments based on hydro-geologic features. The Trustees will then compare sediment mercury concentrations to the 50 and 90 percent toxicity thresholds. Furthermore, the Trustees will investigate sediment concentrations downstream of the confluence of the South and North Rivers. If the currently available information and the results of ongoing investigations are insufficient to determine if sediment within the assessment area has been injured or is insufficient to quantify injury, the Trustees may propose additional site-specific studies (Exhibit 3-4). For example, the Trustees may propose to conduct a site-specific laboratory sediment toxicity test (e.g., Burton et al. 2003).

[11] For concentrations higher than this there is a greater than 50 or 95 percent chance of toxicity to sediment dwelling organisms, respectively.

[12] At the town of Port Republic a hydrologic change occurs - the South River merges with the North River.

EXHIBIT 3-3 EXAMPLES OF MERCURY CONCENTRATIONS IN SOUTH RIVER AND SFSR RESOURCES, REGULATORY CRITERIA AND GUIDELINES, AND THRESHOLD/EFFECTS IDENTIFIED IN THE LITERATURE

RESOURCE		REGULATORY CRITERIA		EXAMPLE THRESHOLD/EFFECTS IDENTIFIED IN THE LITERATURE[7]	
SURFACE WATER	SURFACE WATER	770 ng/L	Chronic Aquatic Life Water Quality Criteria[2]	NA[8]	
		1,400 ng/L	Acute Aquatic Life Water Quality Criteria[2]		
	SEDIMENT	NSP[3]		0.49 ppm[9]	50 percent probability of toxicity
				6.93 ppm[9]	95 percent probability of toxicity
GEOLOGIC	FLOODPLAIN SOILS	5.6 ppm (Elemental) 23 ppm (Mercuric Chloride)	US EPA Screening Level for Residential Soils[4]	NA	
		34 ppm (Elemental) 310 ppm (Mercuric Chloride)	US EPA Screening Level for Industrial Soils[4]	NA	
BIOTA	FISH CONSUMPTION ADVISORIES	1.0 ppm	FDA Action Level[5]	NA	
		0.5 ppm	Virginia Department of Health Action Level[6]		
	FISH HEALTH	NSP		0.2 ppm[10]	NOAEC[11]
	PISCIVIROUS BIRDS AND MAMMALS HEALTH			TBD[12]	
	REPTILES AND AMPHIBIANS				
	TERRESTRIAL BIRDS AND MAMMALS HEALTH				

1: ND - Not Detect.
2: United States Environmental Protection Agency. 2009. National recommended water quality criteria.
3: NSP – No Standard Promulgated.
4: United States Environmental Protection Agency. 2009. Generic SSLs for the residential and commercial/industrial scenarios.
5: United States Department of Food and Drug Administration. Compliance Policy Guides section 540.600.
6: Virginia Department of Health - Division of Environmental Epidemiology. Frequently Asked Questions About Mercury.
7: Exceedence of literature based thresholds/effects indicates likely injury.
8: NA – Not Applicable.
9: Field et al. 2002.
10: Beckvar et al. 2005.
11: NOAC – No Observed Effects Concentration based on multiple biologically relevant endpoints across multiple species.
12: TBD – To Be Determined.

SOIL

Soils are essential for the cycling of elements, minerals, and nutrients through the environment. Injury to soils has occurred when concentrations of a substance are sufficient to cause:

> *(i) A toxic response to soil invertebrates* (43 CFR § 11.62 (e)(9));
>
> *(ii) A phytotoxic response such as retardation of plant growth* (43 CFR § 11.62 (e)(10); or
>
> *(iii) Injury…to surface water, ground water, air, or biological resources when exposed to the substances* (43 CFR § 11.62(e)11))

The Trustees are compiling existing information regarding the presence of mercury in floodplain soils and comparing it to the thresholds noted above. In addition, the SRST is conducting a multi-year floodplain soil investigation to determine the geographic extent of mercury in soil. To evaluate the potential for ecological injury due to elevated mercury levels in assessment area soils, mercury concentrations in soil will be compared to screening criteria promulgated by the EPA and/or adverse effects information in the peer-reviewed literature. Similar to sediment, the Trustees' proposed approach is to divide the floodplain into segments based on hydro-geological characteristics (e.g., likelihood of flooding and habitat type). The Trustees will then compare soil mercury concentration for each segment to the thresholds presented in Exhibit 3-3. Exceedences of these effects thresholds would indicate likely injury. Additionally, the Trustees may propose site-specific studies to further investigate mercury-contaminated floodplain soils (Exhibit 3-4).

BIOLOGICAL RESOURCES

Biological resources, both individually and as a whole, provide ecological (e.g., food web sustainability) and human use (e.g., recreational fishing) services.

Injury to a biological resource has resulted from the release of a hazardous substance if the concentration of the substance is sufficient to:

> *(i) Cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations; or*
>
> *(ii) Exceed action or tolerance levels established under section 402 of the Food, Drug and Cosmetic Act, 21 U.S.C. 342, in edible portions of organisms; or*
>
> *(iii) Exceed levels for which an appropriate State health agency has issued directives to limit or ban consumption of such organism (43 C.F.R. § 11.62 (f)(1)).*

Injury to biological resources can be established by demonstrating one or more of the conditions defined in 43 CFR § 11.62(f)(1,4), including, but not limited to, reduced

reproductive success, behavioral signs of toxicity, physiological malfunctions, and increased mortality.

Injury to fauna can be assessed by reviewing site-specific information regarding mercury concentrations in both abiotic and biotic resources and comparing those concentrations to corresponding adverse effects information from site-specific studies and/or the literature. Exhibit 3-3 presents the biological resources on which the Trustees are focusing, and if available, the regulatory criteria or literature based thresholds/effects levels. Documented toxicity, exceedences of effects thresholds, or exceedences of trigger levels determined by an appropriate agency indicate that injury is likely. The Trustees' proposed approach to evaluating injury to fauna is similar to that for sediments and soils. For each species or species group being evaluated, the Trustees propose to divide the assessment area into segments based on hydro-geologic features and habitat types. Within each segment, mercury concentrations in biota will be compared to the adverse effects information.

The SRST, NRDC, DuPont, and the Trustees have collaboratively investigated multiple species and species groups within the assessment area, including but not limited to, aquatic invertebrates, fish, piscivirous birds and mammals, aquatic insectivores, turtles, frogs, salamanders, bats, and terrestrial invertebrates and songbirds. These studies have confirmed that, compared to reference populations, biota within the assessment area have been exposed to mercury (e.g., Cristol 2006, Hopkins 2006). However, the geographic extent of exposure to Facility-related mercury has not yet fully been quantified for all species groups. There are several ongoing and planned studies designed to address information gaps relating to the geographic extent of exposure (Exhibit 3-4). As each study is completed, the Trustees will review the data and determine if additional information is required.

Adverse effects information for many species groups (e.g., bats and terrestrial songbirds) is not available in the literature and no regulatory criteria or guidelines have been promulgated. As such, site-specific studies are ongoing or planned and will be used to establish a threshold.

EXHIBIT 3-4 SUMMARY OF ECOLOGICAL STUDIES

HABITAT	RESOURCE(S)	STUDY COMPONENTS (STATUS)	APPROACH
RIVERINE	SURFACE WATER	Exceedence of surface water standards (completed)	Evaluate mercury concentrations and extent of contamination in surface water
		Toxicity of sediment (ongoing)	Evaluate mercury concentrations, toxicity, and extent of contamination in sediment
	FISH	Fish health (ongoing)	Evaluate lethal and sub-lethal health effects and geographic extent of contamination
	AMPHIBIANS	Salamander and toad health (ongoing)	
	REPTILES	Turtle health (planned)	
	BIRDS	Aquatic invertivorous bird health (ongoing)	
		Piscivirous bird health (ongoing)	
FLOODPLAIN	GEOLOGIC	Toxicity of floodplain soils (ongoing)	Evaluate mercury concentration, toxicity, and extent of contamination in floodplain soils
	MAMMALS	Bats (ongoing)	Evaluate lethal and sub-lethal health effects and geographic extent of contamination
	BIRDS	Terrestrial invertivore health (ongoing)	
LABORATORY STUDIES	SURFACE WATER	Site-specific sediment toxicity tests (ongoing)	Toxicity tests
	BIRDS, REPTILES, AND AMPHIBIANS	Adult bird health (ongoing)	Evaluate the effects of mercury on the health of captive birds when fed a diet consisting of methylmercury
		Amphibian health (ongoing)	Evaluate the effects of mercury on the health of developing tadpoles when exposed to mercury in a laboratory

CHAPTER 4 | INJURY QUANTIFICATION

Once it has been determined that natural resources have been injured, quantification of that injury is undertaken to establish a basis for scaling restoration and determining damages. Injuries to natural resources can be quantified in terms of the actual measured loss of the specific resource(s), and/or the services that the injured resource would have provided had the release not occurred. According to the DOI regulations, services are defined as,

> *…the physical and biological functions performed by the resource including the human uses of those functions. These services are the result of the physical, chemical, or biological quality of the resource* (43 CFR § 11.14 (nn)).

As described in the DOI regulations:

> *In the quantification phase, the extent of the injury shall be measured, the baseline condition of the injured resource shall be estimated, the baseline services shall be identified, the recoverability of the injured resource shall be determined, and the reduction in services that resulted from the discharge or release shall be estimated* (43 CFR § 11.70(c)).

The Trustees will address these requirements as described below. This approach may be amended as additional information becomes available.[13]

To select and scale restoration options, the Trustees currently anticipate using habitat and resource equivalency analysis (HEA and REA). These methods "*may be used to compare the natural resource services produced by habitat or resource-based restoration actions to natural resource service losses*" 43 CFR § 11.83(c). For human use service losses, the Trustees propose to scale required restoration based on the nature and extent of lost recreational services (e.g., lost and diminished recreational fishing trips). The steps to be followed to quantify injury to support application of these damage determination approaches are discussed further below.

BASELINE

Injury will be quantified based on a reduction in services as compared to the baseline level of services (43 CFR § 11.72(a)). As defined in the DOI regulations, baseline is:

> *The condition or conditions that would have existed at the assessment area had the…release of the hazardous substance…not occurred" (43 CFR § 11.14(e)).*

[13] Final injury quantification will factor in any remedial and response actions and avoid any double counting.

Pursuant to 43 CFR §11.72, baseline can be established through a review of historical conditions and/or conditions in reference areas. In this case, relevant historical data are lacking. Therefore, the Trustees will describe baseline conditions using data from a reference area(s). If it is not feasible to establish baseline conditions through the use of reference areas, the Trustees will evaluate the relevant peer-reviewed literature and if necessary propose site-specific studies.

ECOLOGICAL INJURY QUANTIFICATION

Ecological injury quantification will focus on endpoints that are considered the most biologically relevant (i.e., endpoints that most directly impact a resource's ability to function and provide services), including growth, reproduction, and survival of biota, but may also include evaluation of other measures of health and individual viability. The Trustees propose to quantify injury to natural resources within the assessment area for riverine and floodplain habitats.

RIVERINE HABITAT

The riverine habitat includes the area within the banks of South River and the SFSR and all organisms that rely on the resources within this area. Quantification of injury to riverine habitat within the assessment area will be based on service losses associated with resources that are significant to the natural function of the habitat. These resources may include, but are not limited to:

- **Surface water**: Surface water resources within the assessment area provide ecological services such as habitat for fish and invertebrate species, and feeding, breeding, and nursery functions, as well as human use services such as fishing and boating.
- **Sediments**: Sediments provide ecological services such as habitat for benthic organisms and substrate for aquatic vegetation, as well as human use services including recreational opportunities (e.g., boating and fishing).
- **Biological**: Biological resources within the assessment area include the fauna of the aquatic habitat such as invertebrates, fish, piscivirous birds, amphibians, reptiles, and mammals.

FLOODPLAIN HABITAT

For the purposes of this NRDA, the floodplain habitat includes all areas outside of the river banks of the South River and the SFSR where Facility-related mercury has come to be located. Quantification of injury to floodplain habitat within the assessment area will be based on service losses associated with select resources. These resources may include, but are not limited to:

- **Soil**: Soil provides ecological services such as habitat for soil organisms, the nutrients and water holding capacity necessary to sustain vegetative cover, and substrate for litter decomposition.

- **Biological**: Biological resources within the assessment area include the fauna of the terrestrial habitat such as invertebrates, birds, reptiles, and mammals.

INDIVIDUAL RESOURCES OF SPECIAL CONCERN

For certain resources injuries may be quantified individually (e.g., resources which are unique or of special concern, such as locally rare, threatened or endangered species, or require restoration be scaled based on individual quantification of injuries, etc.). The Trustees are in the process of identifying whether any such resources have been impacted by exposure to Facility-related mercury. To accomplish this, the Trustees are reviewing Federal and State lists of threatened and endangered species, and communicating with local biologists. If such resources are identified the Trustees may propose site-specific studies to quantify injury.

HUMAN USE INJURY QUANTIFICATION

The South River and SFSR provide several human use services such as recreational fishing and boating. The release of mercury from the Facility has impaired the ability of these areas to provide these services. A reduction in services may be quantified based on lost use (e.g., trips, consumption (due to health advisory), etc.), or lost value (e.g., reduction in consumer surplus).[14] The Trustees' general approach to the assessment of human use services will be to estimate lost use based on existing data and to evaluate the benefit of undertaking additional studies for improving such estimates.

RECREATIONAL FISHING

The South River and the SFSR support a regionally significant recreational fishery, with smallmouth bass being the most sought after game fish. Facility-related mercury contamination has likely changed the way that anglers utilize the fishery. Furthermore, since 1977 the Commonwealth of Virginia has issued advisories restricting the consumption of fish taken from the South River and SFSR due to Facility-related mercury contamination.

Common responses that anglers have when faced with chemical contamination and any associated advisories or changes in resource management at their preferred fishing location include:

- Fishing less frequently or not at all,
- Fishing in less desirable locations,
- Traveling further to fish, or
- Converting to catch-and-release angling.

[14] Consumer surplus is the amount individuals would be willing to pay for a good or service above and beyond the cost of that good or service rather than forgo consumption of the good or service. For additional information regarding consumer surplus see Chapter 5.

In order to assess these impacts, the Trustees will evaluate the Virginia Department of Game and Inland Fisheries 2005 South River and Upper SFSR Angler Survey (Bugas 2008). If necessary, the Trustees will propose additional site-specific studies to accurately quantify injury.

BOATING

Aside from recreational fishing, recreational activities in the assessment area potentially impacted by contamination include kayaking and canoeing. The South River and the SFSR are important regional recreational destinations as described in Bugas (2008). The Trustees will evaluate the non-fishing recreational boating use information presented in Bugas (2008) and if necessary propose additional site-specific studies to quantify injury.

ADDITIONAL HUMAN USE SERVICES

In addition to fishing and boating, the Trustees may investigate to what extent the habitats within the assessment area are used by the public for other recreational activities such as bird watching, other wildlife viewing, and duck hunting.

CHAPTER 5 | DAMAGE DETERMINATION

Once injury to Trust natural resources has been determined and quantified, the Trustees must next determine damages for those injuries and evaluate appropriate restoration alternatives. Damages are quantified as a dollar amount sufficient to compensate the public for losses associated with natural resource injuries, or in terms of required restoration actions to be undertaken by the Responsible Party. It is important to note that Trustees are required to spend all recovered dollar damages on natural resource restoration.

As noted in Chapter 4, the Trustees currently anticipate using equivalency based approaches (HEA and REA) to select and scale required restoration projects for ecological injuries. For lost human use services, the Trustees plan to focus on lost and diminished recreational fishing opportunities, and to select and scale restoration options for these lost services based on existing information. To the extent that existing information is not sufficient to establish human use damages, primary research may be undertaken (e.g., development of a Random Utility Maximization model of angler behavior). Once required restoration actions have been selected and scaled, the Trustees will determine the cost of these actions. It is this cost which will represent the final dollar damage determination. The results of the damage determination phase will be presented in a Restoration Compensation Determination Plan (RCDP), which will be released for public review and comment.

To provide focus for the assessment, the Trustees will consider restoration throughout the damage assessment process. Restoration is designed to return injured resources to their baseline condition and to compensate for the resources and resource services that were lost during the period for which damages are assessed. The RCDP will document the approach used by the Trustees to determine the appropriate type and scale of restoration. This document will identify the Trustees' restoration goals, discuss the restoration options considered by the Trustees, present the criteria used in selecting the final restoration actions, and provide a detailed assessment of the type and amount of restoration necessary to effectively compensate the public for the injured natural resources. It will also document the expected cost of these actions, including monitoring costs.

REFERENCES

Adams, J. and C. Rowland. 2003. Aquatic toxicology test methods. Handbook of ecotoxicology: Second Edition. Ed. D.J. Hoffman, B.A. Rattner, G.A. Burton Jr., and J. Cairns Jr. Lewis Publishers, New York, NY.

Barr, J.F. 1986. Population dynamics of the common loon (Gavia Immer) associated with mercury-contaminated waters in Northwestern Ontario. Occasional Paper 56. Canadian Wildlife Service, Ottawa, ON.

Beckvar, N., T.M. Dillon, and L.B. Read. 2005. Approaches for linking whole-body fish tissue residues of mercury or DDT to biological effects thresholds. *Environmental Toxicology and Chemistry* 24(8):2094-2105.

Biodiversity Research Institute. 2007. Mercury in bats from the South River. Presentation to the South River Science Team. June 17.

Bugas, P. 2008. 2005 South River and Upper South Fork Shenandoah River Angler Survey. South River Science Team Meeting: October 22, 2008.

Burton, G., D. Denton, K. Ho, and D. Ireland. 2003. Sediment toxicity testing: issues and methods. Handbook of ecotoxicology: Second Edition. Ed. D.J. Hoffman, B.A. Rattner, G.A. Burton Jr., and J. Cairns Jr. Lewis Publishers, New York, NY.

Cristol, D. 2006. Bird study: Year 2. Presentation to the South River Science Team. October 11.

DuPont Corporate Remediation Group. 2008. Phase I, Year 1 Progress report: Ecological study of the South River and a segment of the South Fork Shenandoah River, Virginia.

Eaton R.D.P., D.C. Secord, and P. Hewit. 1980. An experimental assessment of the toxic potential of mercury in ringed-seal liver for adult laboratory cats. *Toxicol. Appl. Pharmacol*. 55:514-521.

Eggleston, J. 2009. Mercury loads in the South River and simulation of mercury total maximum daily loads (TMDLs) for the South River, South Fork Shenandoah River, and Shenandoah River: Shenandoah Valley, Virginia. US Geologic Service Scientific Investigation Report 2009-5076.

Field, L.J., D.D. MacDonald, S.B. Norton, C.G. Ingersoll, C.G. Severn, D. Smorong, and R. Lindskoog. 2002. Predicting Amphipod Toxicity from Sediment Chemistry Using Logistic Regression Models. *Environmental Toxicology and Chemistry* 21(9):1993-2005.

Hopkins, W. 2006. Differential bioaccumulation and speciation of mercury among four species of turtles in the South River. Presentation to the South River Science Team. October 11.

Liberati, M. 2008a. Corrective action program review. Presentation to the South River Science Team: July 15.

Liberati, M. 2008b. Corrective action program review. Presentation to the South River Science Team: October 21.

Natural Resources Defense Council, Inc. and Sierra Club v. E.I. duPont de Nemours and Company. Consent Decree. United States District Court for the Western District of Virginia Harrisonburg Division. (Civ. Action No. 5:05-cv-30013). June 2005.

Newman, M. and K. Tom. 2006. Periphyton surveys and trophic transfer. Presentation to the South River Science Team. October 11.

Newman, M. and K. Tom. 2008. Mercury trophic dynamics. Presentation to the South River Science Team: October 21.

Newman, M., K. Tom, and X. Xiaoyu. 2009. Mercury trophic transfer model: South River floodplain. Briefing paper to the South River Science Team. October 6.

South River Science Team. 2007. Waynesboro Plant RFI Background. Briefing paper to the South River Science Team. October 10.

South River Science Team. 2009. http://southriversciencteam.org. Last accessed November 27, 2009.

Stahl, R. 2001. Data review and trends. Presentation to the South River Science Team. February 14.

US Environmental Protection Agency. 2009. Mercury in the South River, Waynesboro, Virginia. Available at: http://www.epa.gov/tio/tsp/download/2009_jan_meeting/joel_hennessey.pdf. Last accessed November 27, 2009.

US Environmental Protection Agency. 2008. Invista, Incorporated (formerly DuPont). Available at http://www.epa.gov/reg3wcmd/ca/va/pdf/vad003114832.pdf. Last accessed November 27, 2009.

Wolfe, M.F., S. Schwarzback, and R.A. Sulaiman. 1998. Effects of mercury on wildlife: A comprehensive review. *Environ. Toxicol. and Chem*. 17:146-160.

Wren, C.D., D.B. Hunter, J.J. Leatherland, and P.M. Stokes. 1987a. The effects of polychlorinated biphenyls and methylmercury, singly and in combination on mink. I. Uptake and toxic responses. *Arch. Environ. Contam. Toxicol*. 16:441-447.

Wren, C.D., D.B. Hunter, J.J. Leatherland, and P.M. Stokes. 1987b. The effects of polychlorinated biphenyls and methylmercury, singly and in combination on mink. II. Reproduction and kit development. *Arch. Environ. Contam. Toxicol*. 16:449-454.

APPENDIX A | QUALITY ASSURANCE PLAN

The DOI NRDA regulations require that the Trustees develop a Quality Assurance Plan (QAP) that "satisfies the requirements listed in the National Contingency Plan (NCP) and applicable EPA guidance for quality control and quality assurance plans" (43 CFR §11.31(c)(2)). Such a plan is needed to ensure the validity of data collected as part of the NRDA and to provide a solid foundation for the Trustees' subsequent decisions. Also relevant to this effort are the FWS guidelines developed under the Information Quality Act of 2001. All information developed in this NRDA will be in compliance with these guidelines.

This Plan includes studies that evaluate existing datasets as well as studies that generate new information. With respect to the evaluation of existing data, the study's principal investigator (PI) will carefully document the source of all data, available information about quality assurance (QA)/quality control (QC) procedures used by the original investigator, and any data qualifiers or other information restricting application of the data. This approach will also be applied to new data and analyses developed by Federal and State agencies, academics, and information developed under the auspices of other activities or programs. For new studies that are specifically undertaken to support the NRDA process, appropriate study-specific QAPs will be developed according to the general principles described below.

As noted by EPA (2001), QAPs will "vary according to the nature of the work being performed and the intended use of the data" and as such, need to be tailored to match the specific data-gathering needs of a particular project. The NRDA effort for the South River and SFSR will entail a variety of widely-different data-gathering efforts; therefore, it is not appropriate to develop a single, detailed QAP to cover all these activities. Instead, the Trustees will ensure that individual study plans adequately address project-specific quality assurance issues. The discussion in this document therefore focuses on the required elements of an acceptable study plan.

In general, a study plan must provide sufficient detail to demonstrate that:

- the project's technical and quality objectives are identified and agreed upon;
- the intended measurements, data generation, or data acquisition methods are appropriate for achieving project objectives;
- assessment procedures are sufficient for confirming that data of the type and quality needed and expected are obtained; and
- any limitations on the use of the data can be identified and documented (EPA 2001).

Accordingly, specific study plans developed for this assessment will include the four elements called for by EPA:

- **Project Management** – documents that the project has a defined goal(s), that the participants understand the goal(s) and the approach to be used, and that the planning outputs have been documented;
- **Data Generation and Acquisition** – ensures that all aspects of project design and implementation including methods for sampling, measurement and analysis, data collection or generation, data compiling/handling, and QC activities are documented and employed;
- **Assessment and Oversight** – assesses the effectiveness of the implementation of the project and associated QA and QC activities; and,
- **Data Validation and Usability** – addresses the QA activities that occur after the data collection or generation phase of the project is completed.

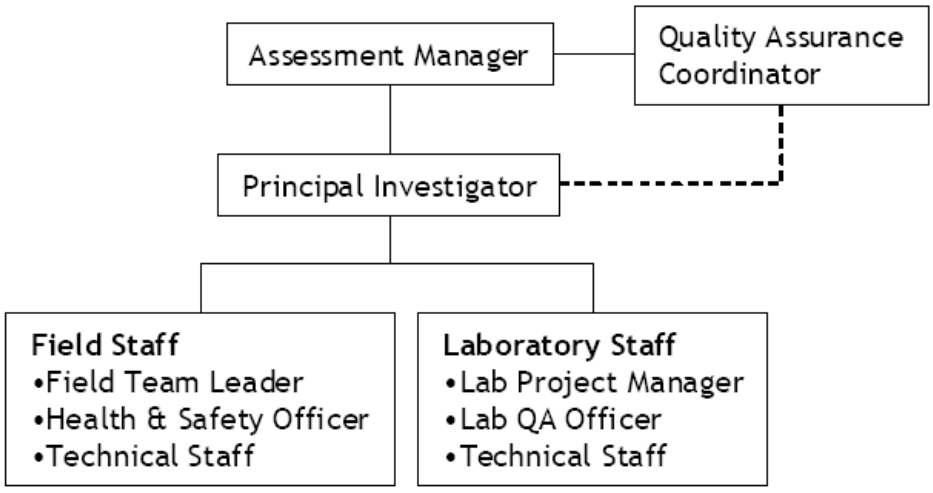
PROJECT MANAGEMENT

Effective implementation of project objectives requires clear project organization, which includes carefully defining the roles and responsibilities of each project participant. Unambiguous personnel structures help ensure that each individual is aware of his or her specific areas of responsibility, as well as clarifying internal lines of communication and authority, which is important for decision-making purposes as projects progress. Individuals' and organizations' roles and responsibilities may vary by study or task, but each person's role and responsibility should be clearly described in the project's study plan. Exhibit A-1 below presents a generic personnel plan for a NRDA project.

The Assessment Manager is the designated Trustee representative (from FWS or the Commonwealth of Virginia) with responsibility for the review and acceptance of the project-specific study plan. This individual is also responsible for ensuring that the project's goals and design will meet the broader requirements of this NRDA. The Assessment Manager coordinates efforts with the Quality Assurance Coordinator and oversees the Study Principal Investigator.

The QA Coordinator oversees the overall conduct of the quality system. Appointed by the Trustees, this individual's responsibilities include, but are not limited to: reviewing/assisting the PI with the development of project-specific study plans; conducting audits and ensuring implementation of both project-specific and overall plans; archiving samples, data, and all documentation supporting the data in a secure and accessible form; and reporting to the Trustees. To ensure independence, the person serving as QA Coordinator will not serve as either the Assessment Manager or as a PI for any NRDA study.

EXHIBIT A-1 PERSONNEL PLAN



Study-specific PIs oversee the design and implementation of particular NRDA studies. Each PI has the responsibility to ensure that all health, safety, and relevant QA requirements are met. If deviations from the study plan occur, the PI (or his/her designee) will document these deviations and report them to the Assessment Manager and the QA Coordinator.

The Field Team Leader (FTL) supervises day-to-day field investigations, including sample collection, field observations, and field measurements. The FTL generally is responsible for ensuring compliance with all field quality assurance procedures defined in the study plan. Similarly, the Laboratory Project Manager is responsible for monitoring and documenting the quality of laboratory work. The Health & Safety Officer (who may also be the FTL) is responsible for ensuring adherence to specified safety protocols in the field.

DATA GENERATION AND ACQUISITION

All studies under the direction of the Trustees that are specifically undertaken in support of the NRDA will have a prepared study plan that will be completed prior to the initiation of any work. These study plans will be submitted to, and approved by, the QA Coordinator or designee. Each study plan should describe and/or include, at a minimum:

- Project objectives;
- Rationale for generating or acquiring the data;

- Proposed method(s) for generating or acquiring the data, including descriptions of (or references to) standard operating procedures for all sampling or data-generating methods and analytical methods;
- Types and numbers of samples required;
- Analyses to be performed;
- Sampling locations and frequencies;
- Sample handling and storage procedures;
- Chain-of-custody procedures;
- Data quality requirements (for instance, with respect to precision, accuracy, completeness, representativeness, comparability, and sensitivity);
- Description of the procedures to be used in determining if the data meet these requirements; and
- Description of the interpretation techniques to be used, including statistical analyses.

In addition, to the extent practicable, laboratories will be required to comply with Good Laboratory Practices. This includes descriptions of maintenance, inspections of instruments, and acceptance testing of instruments, equipment, and their components, as well as the calibration of such equipment and the maintenance of all records relating to these exercises. Documentation to be included with the final report(s) from each study will include field logs for the collection or generation of the samples, chain of custody records, and other QA/QC documentation as applicable.

ASSESSMENT AND OVERSIGHT

To ensure that the study plan for each project is implemented effectively, the QA Coordinator will review quality assurance/quality control plans for all Trustee studies that generate data. The QA Coordinator or designee will also audit all such studies. Audits will include technical system audits (for instance, evaluations of operations) as well as scrutinizing data and reports (for instance, evaluations of data quality and adequacy of documentation).

If, in the professional opinion of the QA Coordinator, the results of an audit indicate a compromise in the quality of the collection, generation, analysis, or interpretation of the data, the QA Coordinator has the authority to stop work by oral direction. Within two working days of this direction, the QA Coordinator will submit to the Trustee Council a written report describing the necessity for this direction. The Trustee Council will review the findings of the QA Coordinator and render its own determination.

DATA VALIDATION AND USABILITY

In addition to the assessment and oversight activities described previously, analytical data will be considered for validation by an independent third party. Prompt validation of analytical data can assist the analyst or analytical facility in developing data that meet the requirements for precision and accuracy. If undertaken, it is expected that data validation will use the project-specific study plans and EPA Guidance on Environmental Verification and Validation (EPA 2002).

REFERENCES

US Environmental Protection Agency. 2001. EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5), March 2001.

US Environmental Protection Agency. 2002. EPA Guidance on Environmental Data Verification and Data Validation (EPA QA/G-8), November 2002.

U.S. Department of the Interior Approval of the South River and South Fork of the Shenandoah River Natural Resource Damage Assessment

Damage Assessment Plan

In accordance with U.S. Department of the Interior policy regarding documentation for natural resource damage assessment and restoration projects (521 DM 3), the Authorized Official for the Department must demonstrate approval of draft and final Assessment Plans with concurrence from the Department's Office of the Solicitor.

The Authorized Official for the South River and South Fork of the Shenandoah River Natural Resource Damage Assessment case is the Regional Director for the U.S. Fish and Wildlife Service's Northeast Region.

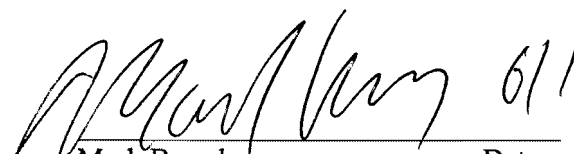
By the signatures below, the Assessment Plan (AP) is hereby approved.

Approved:

6/13/11

Acting Marvin E. Moriarty — Date
Regional Director
Northeast Region
U.S. Fish and Wildlife Service

Concurred:



6/14/2011

Mark Barash — Date
Senior Attorney
Northeast Region
Office of the Solicitor