Section 5: Project Description

1. Project Objectives:

The West Struve Slough Enhancement and Habitat Restoration Project will implement the third phase of a highly successful wetland enhancement project on the West Struve Slough

Unit of the California Department of Fish and Wildlife owned, Watsonville Sloughs Ecological Reserve. This project will remove 3 acres of poison hemlock (*Conium maculatum*), an invasive annual plant species, and restore diverse native marsh, riparian woodland and wet meadow habitat. The project will sequester greenhouse gases emissions through the replacement of large stands of an annual/bi-annual invasive weed with perennial marsh, riparian woodland, and wet meadow native plant communities, while providing a variety of important co-benefits. Co-benefits include enhancement of important wetlands and fish and wildlife habitat including State listed threatened and species of special concern, support of climate change adaptation for freshwater wetland and coastal prairie associated wildlife, improvement to Department of Fish and Wildlife lands, improved connectivity to associated wetland and upland habitats on the Ecological Reserve, and increased native plant diversity and cover along with greatly decreased invasive plant species.

Specific project objectives include:

1) Remove 3 acres of invasive plant species and restore 3 acres of native riparian woodland and wet meadow habitat

2) Enhance 60 acre seasonal freshwater wetlands on the Watsonville Sloughs Ecological Reserve through the restoration of adjacent native habitat areas;

3) Sequester at least 47.1 tons of C over a 20 year period, with greater benefits expected beyond the 20 year period. Average annual sequestration of carbon is expected to be 2.7 tons of C;

4) Provide a critical habitat corridor and linkage between seasonal freshwater wetland and adjacent grassland and coastal scrub upland habitat along a 3,700 ft. linear corridor

5) Develop habitat areas design to State and Federally listed threatened and endangered wildlife species, including the California red-legged frog (Rana draytonii), and many ground nesting and marsh associated bird species listed on the California bird species of special concern list, including golden eagle (Aquila chrysaetos), northern harrier (Circus cyaneus), and the white tailed kite (Elanus leucurus).

6) Significantly increase native plant diversity, habitat structure and complexity to benefit sensitive and State and Federally listed wildlife species, through the installation of over 8000 native plants and over 70 different native grass, rush, sedge, tree and shrub species, converting large sections of wetland habitat on the reserve from a single invasive plant species to highly diverse habitat areas.

7) Improve water quality and reduce invasive species presence in the associated wetlands and surrounding wetland areas throughout the Watsonville Slough System and watershed through the establishment of deep rooted perennial riparian buffers that will decrease nitrates in the water column and help to control the spread of water bourne seed from invasive plant species in downstream wetlands.

2. *Background and Conceptual Models:*

Proposed work on this project will occur on the West Struve Slough unit of the Watsonville Slough Ecological Reserve, owned by the California Department of Fish and Wildlife. This work represents the third phase of a 10 year effort to remove poison hemlock, an invasive plant species, and restore diverse native habitat on the property.

Background and Site History: The Watsonville Sloughs Ecological Reserve was acquired by the California Department of Fish and Wildlife in 1984 as part of a permit condition to a peat mining company that stipulated that once mining activity was completed the property would be transferred to the State. Prior to ownership by the peat mining company, and ongoing during the mining company ownership period, the property was used as rangeland as part of a dairy operations, for hay production, and row crop production. In the process of the farming activity that spanned the late 1800's to the State's acquisition there was significant disturbance associated with plantings of non-native and invasive forage crops and intensive grazing and farming, resulting in the loss of nearly all native plant cover on the property. Once the property was transferred to the State all agricultural uses ceased, however, the impacts of the historic farming and associated disturbances were significant, leaving the property with greatly degraded habitat.

In 1995, the non-profit organization, Watsonville Wetlands Watch, began managing volunteer habitat restoration projects on the property, and continues to do so to this day in close collaboration and cooperation with the California Department of Fish and Wildlife. Beginning in 2003, funding was provided by a variety of grant sources to support the habitat restoration work, including grants from the California Coastal Commission Whale Tail Program, the Wildlife Conservation Board (current funder for phase II of this project), the Regional Water Quality Control Board and the National Fish and Wildlife Foundation. Work has focused on removal of invasive plants and restoration of wetland and riparian habitat areas along with improvement native coastal prairie grasslands. Through these efforts, there has been significant improvement to the habitat quality of the property and significant increase in native plant habitat areas. Through the first two phases of this effort, over 3 acres of poison hemlock have been removed and restored to native riparian woodland and wet meadow habitat along 1800 linear feet of the West Struve Slough wetland. These areas have maintained strong native plant cover over this time, with over 90% native cover.

The Watsonville Sloughs Ecological Reserve, on which proposed work will take place, is a part of the greater Watsonville Slough System, the third largest remaining freshwater slough system on the California coast. The slough system is a highly productive and valuable system that supports over 260 resident and migratory bird species and 23 native plant and animal species listed as State and Federally threatened, endangered, and species of special concern, including the California red-legged frog (federally listed threatened), tricolored blackbird (California species of special concern), and Santa Cruz tarplant (Federally listed endangered).

Current Conditions: While previous restoration efforts have improved habitat conditions on the property, there continues to be a great need restore wetland and upland habitat. Currently there remain approximately 4.5 acres of dense, monocultural stands of the invasive plant poison hemlock within the West Struve Slough unit of the ecological reserve.

Poison hemlock is an annual (sometimes bi-annual) plant species that excludes all other plants within a 30' to 50' band along the wetland edge through its aleopathic properties and growth habitat. Hemlock stands greatly limit available habitat and connectivity between the important upland habitat and seasonal freshwater wetland habitat, impacting a wide range of wildlife species, including grassland dependent and ground nesting bird species, including the northern harrier, burrowing owl, and white tailed kite (all California bird species of special concern), and sensitive mammals, reptiles, and amphibians, including the California red-legged frog (federally listed threatened), and the Western pond turtle. In addition to wildlife habitat needs, the potential of the property and associated habitat areas to sequester greenhouse gases has been greatly limited due to the loss of seasonal wetland, riparian, and wet meadow habitats and their replacement with predominantly annual invasive plant species that do not sequester nearly as large of a quantity of greenhouse gases.

Conceptual Models for Project Benefits:

Native Habitat Restoration Benefits: Restoration of native riparian woodland and wet meadow habitat in place of large monocultural stands of invasive plants on the Watsonville Sloughs Ecological Reserve is an important practice with property and watershed-wide benefits. It is important habitat restoration work have real and sustained benefits to native plant populations, wildlife, water quality, water supply, and channel stability.

Wetlands that become dominated by invasive plants often support lower numbers of animal species, by impacting the food webs and greatly limiting habitat diversity and canopy architecture. Large populations of invasive plants can create a positive feedback loop increasing susceptibility to greater invasion through increased bank destabilization and increased colonization by greater numbers of invasive plants[1]. The restoration process acts to stop the positive feedback loop and cascading impacts to wildlife, water quality and native habitats.

Therefore the replacement of hemlock stands with native riparian woodland and wet meadow habitat will control the spread of invasive plant species, provide water quality benefits associated with increased nutrient uptake and wetland edge stabilization and support a wide range of wildlife species through the improved habitat. It is critical that these habitat benefits provide long term and sustained benefit over time. Over the course of the past two decades of restoration work in the Watsonville Slough System, we have seen the benefits of this work both in developing sustained highly diverse habitats that are not susceptible to invasion as well as benefits to sensitive wildlife species. Burrowing owls, nesting bald eagles, nesting osprey, short eared owls, tri-colored blackbirds and other species are examples of previously extirpated wildlife species that have returned to the sloughs system during this course of the dramatic environmental changes within the slough system and watershed.

Seasonal freshwater wetlands on the Watsonville Sloughs Ecological Reserve also support

[1] Joy B. Zedler and Suzanne Kercher (2004) Causes and Consequences of Invasive Plants in Wetlands: Opportunities, Opportunists, and Outcomes, Critical reviews in Plant Sciences, 23:5, 431-452

water supply needs in the Pajaro Valley. While the wetland does not provide significant replenishment of the ground water aquifer due to the underlying clay layers, the wetland is located just upstream of the Pajaro Valley Water Management Agencies water recycling project, which takes a permitted amount of surplus water in high winter flows for recycled water projects in the Pajaro Valley. Improved water quality in West Struve Slough, associated with this project is an important strategy for increasing water supply and availability in the region.

Greenhouse Gas Emissions Reduction: In order for this project to result in a net reduction in greenhouses gases, it is important that the reductions be in addition to normal and on-going operations that produce greenhouse gas (GHG) reductions beyond what would occur otherwise, that reductions are quantifiable, and that there is a high degree of permanence and certainty to the best available science of the GHG reduction.

Work over the past two decades removing hemlock and restored native wetland communities demonstrates that the restored native habitats are maintained nearly hemlock free, with complete improvement of native habitat diversity and structure. Without additional funding this work will not occur, as there is no mechanism or funding for normal or on-going operations to continue to the wetland restoration work.

Greenhouse gas emissions reduction calculations are based several studies that have evaluated a wide range of activities and temperate wetland types and their associated carbon sequestration capabilities, including in a wide range of studies from agro-forestry to wetland science. Greenhouse gas emissions reductions for this project are based on the application of restoration practices that will remove large stands of shallow rooted annual invasive plants and replace them with deep rooted perennial riparian woodland and wet meadow habitats including native shrubs, trees, grasses, sedges, and rushes. Carbon sequestration will be greatly increased as a result of restoration activity due to: greatly increased capability of the restored wetland to store soil organic matter, the increased above ground woody and herbaceous biomass capable of on-going sequestration, the significantly greater annual growing season (from 6 – 7 months to year round), and the stabilization of recently and historically disturbed areas[2]. Further detail on the calculations of quantities of greenhouse gases removed is detailed in Section 6. Expected quantitative Results later in this proposal.

While the projection of greenhouse gas emissions are based on 20 year projections, longer time scales are expected to provide on-going and permanent reductions of the same order or potentially increased rates. This assumption is based on long-term research and evaluation of restored wetlands that have shown that restored wetlands evaluated for soil organic carbon content 35 years post restoration had soil-forming factors that increased significantly: 73% for litter and biomass and 90% for standing biomass of their natural reference levels. These wetlands had established larger root systems that penetrate the lower soil layers and encourage vertical distribution of soil organic matter[3]. Findings such

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[2] Baldocchi, Dennis (2008) 'Breathing' of the Terrestrial Biosphere: Lessons Learned from a Global Network of Carob Dioxide Flux Measurement Systems, Australian Journal of Botany 56 (1) 1-26

[3] Balantine, Katherin and Schneider Rebecca (2009) Fifty-five years of soil development in restored freshwater depressional wetlands, Ecological Applications, 19(6), 2009, 1467- 1480

as this support the assumption of permanence and on-going greenhouse gas reductions associated with the proposed work.

This project is not anticipated to provide a net increase of nitrous oxide or methane due to the conditions of the site that do not include oxygen depleted and flooded environments conducive to the emissions of these two greenhouse gases. Further discussion of these assumptions is included in Section 6. Expected Quantitative Results.

3. *Detailed project description, including all tasks to be performed:*

The West Struve Slough Enhancement and Habitat Restoration project will restore 3 acres of native riparian woodland and wet meadow habitat along 3700 linear feet of Struve Slough within the Watsonville Sloughs Ecological Reserve, owned by the California Department of Fish and Wildlife. The goals of this project include restoration of critical wetland habitat areas within the Watsonville Slough System to support a diversity of sensitive fish and wildlife species, reduction in greenhouse gasses through the sequestration of atmospheric carbon dioxide, the improvement of wetland functions with benefits to water quality and water supply, and the creation of a demonstration project that will serve to further advance watershed restoration and improvements locally and regionally.

Proposed work was planned and designed in close coordination several partner agencies, including the California Department of Fish and Wildlife, the County of Santa Cruz, the Resource Conservation District of Santa Cruz County, and others. Resulting project goals and objectives are designed to support the goals of larger and more regional natural resource management and enhancement plans, including the Watsonville Slough System Conservation and Enhancement Plan (2003), the Santa Cruz County Integrated Water Management Plan (2014), and the U.S. Fish and Wildlife Service California Red-legged frog Recovery Plan, (2002) – as the project location is within a critical habitat designation for the California Red-legged frog. As such, proposed work is designed to support watershed wide efforts to restore and enhance native riparian woodland, wet meadow, and wetland habitats and represents a high priority effort toward this goal that will support linkages between restored wetland and restored wildlife corridors on this property to adjacent wetlands with past, current, and planned restoration work. Work proposed under this project will also leverage recent and current efforts to restore native riparian woodland and wet meadow habitat on the property.

Work to restore native riparian woodland and wet meadow habitat areas will entail the removal of 3 acres of existing monocultural stands of poison hemlock (Conium maculatum), and the replacement of those stands with a highly diverse assemblage of native plant material, grown from watershed specific stock at the Patrick Fitz Wetlands Educational Nursery, located across the street from the project site on the Pajaro Valley High School campus. All native plant material is harvested and grown by staff, volunteers, and paid intern-students of the Watsonville Wetlands Watch and collected with the Pajaro Valley watershed with an emphasis on the Watsonville Slough System watershed. This is done in order to increase genetic diversity within the local native plant populations and maintain local genetic traits, important to long term sustainability and adaptation to changing climate and other environmental factors. Native plant material collection is done according to best

practices to maximize gene pool diversity (i.e. collecting from at minimum 50 parent plants for propagule collection, and growing all plant material by seed when possible), in order to provide native plant material that is most able to adapt to any environmental changes over time, including those associated with climate change. A large diversity of native plants is utilized in order to provide a rich and diverse habitat structure with flowering periods of plants that vary throughout the year. This is done both to maximize the impacts of available habitat for wildlife that currently utilize the Reserve as well as to create a wetland habitat that supports long term adaptation and resiliency for changing climates and environmental conditions.

In order to initiate the native habitat establishment, poison hemlock will be mowed with either a tractor mower or gas powered weed-eater during summer months, after the hemlock has gone to seed. The timing of this is done in order to start work after the bird nesting period and avoid impacts to wildlife. Occasionally, hemlock tap roots will remain viable after mowing and this case these living tap roots will be removed by either hand grubbing or rototilling. After clearing and grubbing, biodegradable wood chip or rice straw mulch will be applied to the soil surface at the depth of 4 – 6 inches to ensure that hemlock seeds do not germinate at the start of the following year's growing season. The hemlock seed bank is believed to be no greater than 7 years, and so key to this practice is the maintenance of this site hemlock free for this time period. This is done through the installation and establishment of dense native plant communities that do not leave any exposed soil where hemlock seedlings can re-grow. Biodegradable wood chip mulch will be sourced from 100% weed free sources. We work closely with our providers to utilize only weed free post construction wood, as opposed to tree trimmings or vegetation, or order to eliminate the possibility of the introduction of weeds from the wood chip mulch. Wood chip mulch is spread primarily by both hand but also may include use of a small tractor with a bucket attachment.

In winter months, we will commence installation of native plants that have been grown from locally collected seed sources. For planting, plant composition and design will be modeled on nearby reference sites and will include native grasses, sedges, rushes, shrubs, and trees. Plants will be maintained with irrigation during the dry months for approximately one season after planting if needed, though most often natural rain fall is sufficient for establishment. The installed native plants will be irrigated only as needed and until plants become self-sustaining.

Native plantings and invasive plant removal work will be divided into two separate geographic areas and implemented over two years of work (i.e. two phases).

Three years of maintenance is included for the phase I planting areas and two years of maintenance is included for this project as a part of the establishment phase maintenance for the phase II planting area. Maintenance work will entail continued removal of the small populations of hemlock plants or other non-native invasive plants that germinate during spring and summer months. This will primarily be accomplished with hand removal by both staff and volunteers, however there in the case of Himalayan blackberry (Rubis discolor), a highly invasive plant, and an approved herbicide application will be made by a qualified professional. Maintenance may also include use of a flame torch weeder to remove any hemlock seedlings that grow during winter months. Long-term maintenance is critical to the success of any restoration project. This will be accomplished by both Watsonville Wetlands Watch staff and our robust volunteer program. Each year we receive over 3000 hours of

volunteer labor to support restoration projects by students and community volunteers. This work is also supported by local and national businesses and corporations that help to sustain this effort. Due to the successful establishment of native plant material and the relatively short lifespan of poison hemlock seeds in the seed bank, long term maintenance work is not anticipated to be significant, as we have found that one a diverse native habitat has established, and the prior disturbance regime (i.e. historic farming and grazing) has been removed, the new habitat area is highly resistant to invasion by invasive plants.

All work proposed within this project will be undertaken and managed by personnel of the non-profit agency, the Watsonville Wetlands Watch, in close coordination with the partner agency, the California Department of Fish and Wildlife. Some contract labor, including the California Conservation Corps, will be utilized to support activities such as clearing and grubbing of invasive plants, installation of wood chip mulch, planting of native plants, and project maintenance. The work areas included in this proposal are identified in the Appendix of this application form as Exhibit A: Project Location Map, and Exhibit B: Work Plan.

Biological monitoring in order to assess the effectiveness of the restoration project will be conducted through the Watsonville Wetlands Watch's Project Tierra – a citizen science monitoring program that trains and leads volunteers and local students in monitoring of bird populations along permanent transects and from permanent points, water quality monitoring, and monitoring of aquatic invertebrate populations. This work will help to quantify impacts to wildlife populations and water quality associated with the proposed restoration work. Monitoring of the percent cover of native vegetation within the restored area will be accomplished along permanent transect lines utilizing the point intercept method.

As a key goal of this project is the sequestration of greenhouse gases, monitoring, reporting of findings. This will be undertaken through the monitoring of baseline soil organic carbon and annual sampling for four years post restoration along with associated reporting. In addition to soil organic matter monitoring, a baseline assessment of litter and above ground biomass will be conducted pre and post restoration in order to document the impact of wetland restoration work on greenhouse gas emissions reductions.

A photo documentation of past work that is similar in nature is located in the appendix of this document for reference.

4. ***Timeline:***

The project timeline for project work is planned to include the following:

Task and Anticipated Timeline:

Monitor and record baseline soil organic matter content: August 2015

Phase I project implementation:
Native plant production: June 2015 through December 2015.
Invasive Plant Removal and Site Preparation: September and October 2015

Native Plant Installation: November 2015 – February 2016;
Maintenance during the Establishment Phase: March 2016 – June 2019
Biological monitoring: semi-annually 2015 - 2019

Phase II project implementation:
Native plant production: December 2015 – December 2017
Invasive Plant Removal and Site Preparation: September and October 2016; September and October 2017
Native Plant Installation: November 2016 – February 2017; November 2016 – February 2018
Maintenance during the Establishment Phase: March 2017 – June 2019
Biological monitoring: semi-annually 2015 - 2019

Monitoring and Reporting:
Monitor and record post restoration soil organic matter content, litter and above ground biomass, native vegetation percent cover: June 2019

Final Reporting: August 2019
Final Invoice Submission: August 2019

5. ***Deliverables:***

Deliverables for this project will include:

1. GIS maps and associated GPS data/metadata of wetland restoration activity locations
2. GIS maps and associated GPS data/metadata associated with soil organic carbon monitoring
3. Final report of biological monitoring assessement
4. Final report of wetland restoration activity, project implementation and maintenance summary, photo point documentation, soil organic carbon content monitoring results, and greenhouse gas sequestration calculations
5. Final list of native plants installed
6. Photo-point monitoring documentation

All data and final reports generated as a result of this project will be made available to the public. The final project report will be published on the Watsonville Wetlands Watch website, as well as available for any CDFW purposes. In the published report, there will contain a statement that all GIS and GPS data is available upon request to the public.

6. ***Expected quantitative results (project summary):***

The science of greenhouse gas sequestration and emissions modeling is relatively young and there continues to be discussion of monitoring methodology and methods to quantify impacts. In developing a quantitative assessment of greenhouse gases sequestered from our proposed project we conducted an extensive review of the literature of the subject for all applicable study sites that mirror our conditions. We then cross referenced these studies and similar carbon sequestration quantities across the results from literature reviews in order to ensure

consistency of methodologies and greenhouse gas sequestration rates on an annual and a long term basis for this project.

Carbon Sequestration:

Based on this review we estimate that the impact from our project will be between 2.7 and 5.1 tons C per year with 20 year values ranging from 54.0 to 101.1 tons C. This range takes two factors into account. The lower figure of the range is based on a study of shrub-associated temperate freshwater wetland communities and their annual sequestration rates, which mirrors the post restoration native riparian woodland and wet meadow wetland community profile that will result from the proposed restoration work wherein, the recorded carbon sequestration rate was 202 g C per square meter per year[4].

The larger figure of the range expressed above 5.1 tons C annually, is derived from an estimate provided by the United States National Agroforestry Center assessment of the potential for windbreaks and riparian buffers established on cropland to sequester greenhouse gases. This study estimated that if 5% of the 85 million hectares of U.S. cropland were converted to windbreaks and riparian buffers there would be a net sequestration of 58 M t C in 20 yrs. As our project was previously farmed, we felt that this provided a high-end estimate of the carbon sequestration potential of the site.

For the purpose of our estimate however, we used the conservative annual estimate of 2.7 tons C and the 20 year estimate of 54.0 tons C, as referenced in the shrub associated temperate wetland community monitoring. We did not factor in any sequestration associated with the wetland adjacent to where the riparian woodland and wet meadow restoration will take place.

In order to account for the carbon footprint of construction related to the wetland restoration project, we considered vehicle miles traveled for materials delivery, tractor work for clearing and grubbing, and vehicle miles traveled for staff and volunteer labor. Since a larger percentage of the restoration work is proposed to be accomplished with hand labor (i.e. native plantings, application of wood chip mulch, hand weeding of invasive plants) the carbon emissions associated with construction related to transportation, materials hauling, materials production, and tractor operations is not expected to be significant relative to the net reduction of carbon. We used a high end estimate for carbon emissions of ½ ton of carbon per year (3.67 tons CO2) for the first two years of construction and ¼ ton of carbon for year for the second two years of maintenance.

In order to calculate our final net carbon sequestration for the project we assumed the following:

1. Assumed greenhouse gas sequestration of the restoration work of 2.7 tons of C and a 20 year estimate of 54.0 tons of C, per referenced conditions as sited above
2. Assumed carbon emissions associated with construction of 1.5 tons of C over the 4 year period
3. Assumed that the restored wetlands will take 4 years to achieve the level of C sequestration as our reference condition as it develops from its current baseline to a

[4] Bernal, B. and Mitsch, W.J. (2012), Comparing carbon sequestration in temperate freshwater wetland communities. Global Change Biology, 18: 1636 -1647

mature native riparian woodland and wet meadow habitat, and that during that 4 transition period only ½ of the 2.7 tons of C expected to be sequestered will actually be sequestered, yielding 5.4 tons of C sequestered during the initial 4 year period.

Net carbon sequestration for the project is therefore assumed to be 47.1 tons of C after 20 years, as seen in Table 1. that follows:

Table. 1 Net Greenhouse Gas Sequestration for the West Struve Slough Enhancement and Habitat Restoration Project

	Year 1 -4	Year 4 - 20	Subtotal	Year 20 – 50*
Carbon sequestration associated with restoration	5.4	43.2	48.6	81
Carbon emissions associated with construction	-1.5	0	-1.5	0
Total Net GHG Reduction after 20 years			47.1	
Total Net GHG Reduction after 50 years				128.1
				Units = tons of C

**The 50 year time frame is referenced, though the 20 year time frame is considered for the grant objective calculations.*

Carbon sequestration is additional, in that it would not occur without action and funding directed toward the restoration process, chiefly that the current conditions would remain the same until action or intervention were to be taken. It is considered permanent in that well established riparian woodland and wet meadow habitat on this property and others is highly resistant to post-restoration invasion. Poison hemlock removal practices and native wetland restoration practices have been employed on this property for over a decade with both initial and sustained successful establishment of restored native habitats. The commitment to long term maintenance of the project site will also support the long term reduction of greenhouse reduction. As the riparian woodland develops in particular, there is expected to be on-going and deep storage of organic carbon in the soil profile. Risks toward reversal would include post-restoration invasion by poison hemlock and associated loss of restored wetland habitat or conversion of land uses. Long term and sustained management and maintenance will be a preventative measure if poison hemlock or other annual invasive plants begin to establish, however the planting of a wide diversity of trees, shrubs, and understory plants will be highly resistant to this type of invasion. As the project is located on a permanently protected California Department of Fish and Wildlife Ecological Reserve, conversion of land uses will not occur.

Nitrous oxide and Methane Emissions:

Methane and nitrous oxide are not anticipated to be produced as a result of the proposed restoration work. Restoration of wetlands, for example in the form of a conversion of a drained to flooded land use type, has been shown to increase methane emissions, with a range of 39

to 53 g C per meter squared per year[5]. Methane production and emissions are associated with the flooded conditions. As proposed restoration work is above mean high water and generally not within the flooded area, we do not expect any methane emissions associated with the project. Further the project will have no impact on the flooding regime of the project site, with the exception of a negligible impact of greater water use in the vegetation adjacent to the wetland associated with the increase in standing biomass (vegetation).

Similarly, the conditions present within the proposed project are not anticipated to produce nitrous oxide. It is recognized that denitrification can lead to the emissions of nitrous oxide and that as soil organic carbon increases nitrous oxide emissions increase. It is also recognized that soils containing the highest moisture content emit the highest quantities of nitrous oxide, in particular anaerobic soil conditions[6]. Riparian woodlands that are undisturbed however have been shown to have negligible nitrous oxide emissions[7]. In light of these findings and the fact that restoration work will occur above mean high water, nitrous oxide emissions are expected to be negligible.

7. ***Protocols:***

Greenhouse Gas Emissions: Net greenhouse gas reductions will be based on several key metric, as listed below. Each metric will be monitored with specific methods of measurement, evaluated and reported.

Qualitative Metrics:

1. Restored Vegetation/Vegetation Establishment: Successful conversion of annual ruderal invasive plant areas to restored native woody riparian and wet meadow habitat that is structurally diverse and comprised of woody and deep rooted perennial plants is critical to the long term sequestration of greenhouse gases.

   Monitoring: Vegetation monitoring will be accomplished along permanent transect lines in order to determine percent cover of native and non-native vegetation. Vegetation establishment will also be monitored with permanent photo point stations, in order to document establishment over time.

   Reporting: Vegetation monitoring results and photo point documentation monitoring will

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[5] Knox, H., Sturtevant, C., Matthes, J.C.m, Koteen, L., Verfaillie J., Baldocchi, D. (2014) Agricultural peatland restoration: effects of land-use change on greenhouse gas (Co2 and CH4) fluxes in the Sacramento-San Joaquin Delta. Global Change Biology gcb 12745

[6] US EPA, Methane and Nitrous Oxide Emissions from Natural Sources, 2010, Office of Atmospheric Programs, Washington D.C.

[7] Audet, J., Hoffmann, C., Andersen, P. (2014) Nitrous oxide fluxes in undisturbed riparian wetlands located in agricultural catchments: Emission, uptake and controlling factors. Soil Biology and Biochemistry Volume 68, January 2014, 291 - 299

be included in the final report for the project. Vegetation monitoring results and an associated discussion will include percent cover of native vegetation, percent cover of non-native vegetation, and percent cover of vegetation for optimal greenhouse gas sequestration. Based on vegetation monitoring results, a calculation of greenhouse gas sequestration will be made based on assumptions based on the best available science within peer reviewed studies at the time of the report. Photo-point documentation will be utilized to characterize existing/baseline conditions and support the associated discussion. Beyond the reporting timeline, vegetation monitoring and photo point documentation will be continued by Watsonville Wetlands Watch staff, volunteers, and students as part of educational curriculum with matching funds that are sustained by private foundations and donations to support environmental education and monitoring with programs associated with the Patrick Fitz Wetlands Educational Resource Center.

Quantitative Metrics

2. Soil Organic Carbon Content. Soil organic carbon content and its change over time, is a quantitative metric that will reflect sequestration of greenhouse gases, specifically atmospheric carbon dioxide within the restored wetland areas. Through the conversion of annual invasive weeds to perennial riparian woodland and wet meadow habitat, soil organic carbon will increase as a result of far greater root masses and associated carbon in both the shallow and lower layers of the soil profile, increased microbial and biological activity in the soil, and longer term incorporation of increased above ground litter into the soil profile.

   Monitoring: Monitoring for soil organic carbon content will be utilized in order to establish baseline conditions of the site and post restoration conditions as a means to quantify greenhouse gas sequestration. Monitoring will be accomplished at two stratifications within the soil profile, with sufficient samples to provide statistically significant measurement.

   Reporting: Reporting of results will be included in the final report for the project and will provide a basis for increasing knowledge of how conversion of invasive plant species and associated characteristics of annual vegetation into riparian woodlands and wet meadow wetlands improves organic carbon content at varying depths at the soil profile. While there is some knowledge of this within the scientific community, greater study of this is warranted given the growing interest in carbon sequestration and its benefits. Beyond the reporting timeline, soil organic carbon content monitoring will be continued by Watsonville Wetlands Watch staff, volunteers, and students as part of educational curriculum with matching funds that are sustained by private foundations and donations to support environmental education and monitoring with programs associated with the Patrick Fitz Wetlands Educational Resource Center.

3. Above Ground Litter and Biomass. Above ground litter and biomass is another metric that will help to quantify sequestration of atmospheric carbon within the restored wetland areas, as this measurement will express the increased of stored carbon within the wetland as well as the increased ability of the restored area to uptake additional carbon as a result of greater biomass and associated demand for atmospheric carbon dioxide.

Monitoring: Monitoring for above ground litter and biomass will be utilized in order to establish baseline conditions of the site and post restoration conditions as a means to quantify greenhouse gas sequestration. Monitoring will be accomplished across the site with sufficient samples to provide statistically significant measurement.

Reporting: Reporting of results will be included in the final report for the project and will provide a basis for increasing knowledge of how conversion of invasive plant species and associated characteristics of annual vegetation into riparian woodlands and wet meadow wetlands improves atmospheric carbon capture. Beyond the reporting timeline, measurement of litter and above ground biomass will be continued by Watsonville Wetlands Watch staff, volunteers, and students as part of educational curriculum with matching funds that are sustained by private foundations and donations to support environmental education and monitoring with programs associated with the Patrick Fitz Wetlands Educational Resource Center.

Co-benefits: Co-benefits include improvement to water quality, habitat quality, native plant species present vs. invasive plant species, increased support for sensitive wildlife species, and support for local water supply.

Monitoring will be accomplished in the following ways:

Table 2. Co-benefits	
metric	***monitoring method***
habitat quality and associated wildlife benefits	bi-annual bird population monitoring at established transects and point locations within the restoration site and throughout the property
water quality	quarterly water quality sampling on this property and throughout the slough system
native plant species present	documentation of native plants planted on site and monitoring of vegetation cover for percent native and non-native cover along permanent transect lines

Reporting of the metrics and associated monitoring results as listed above will be included within the final report of this document. These results will both provide a measurement for co-benefits and also help to further the understanding of the impacts of restoration of riparian woodlands and wet meadows adjacent seasonal on bird populations. This type of information is particularly important in light of climate change, changing environmental conditions and habitats and the impacts and associated needs of sensitive and declining bird populations.

8. ***Literature Cited:***

1. Audet, J., Hoffmann, C., Andersen, P. (2014) Nitrous oxide fluxes in undisturbed riparian wetlands located in agricultural catchments: Emission, uptake and controlling factors. Soil Biology and Biochemistry Volume 68, January 2014, 291 – 299

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