Adaptation Actions To Reduce Impairment of Indian River Lagoon Water Quality Caused by Climate Change Funding provided by the IRL NEP

> Presented to: UF Water Institute Symposium February 25, 2020 Gainesville, Florida

> > By:

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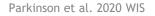




Overall Project Goal

2

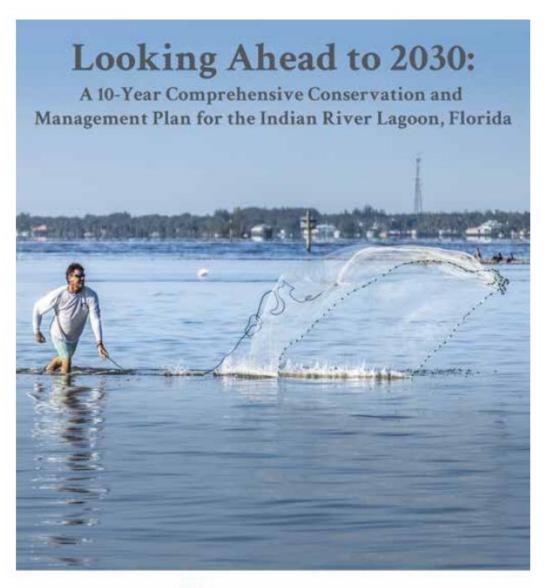
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- 2. Prioritize risks
- 3. Formulate action plans to reduce risks



Overall Project Goal

3

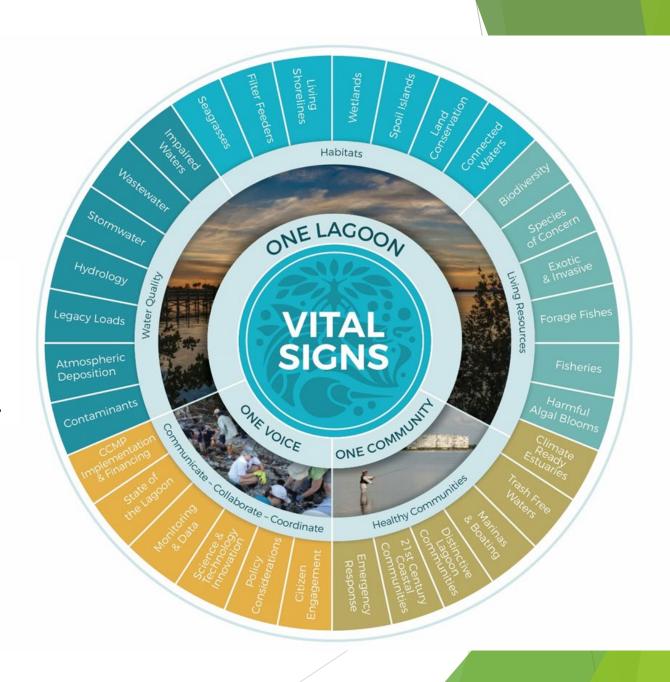
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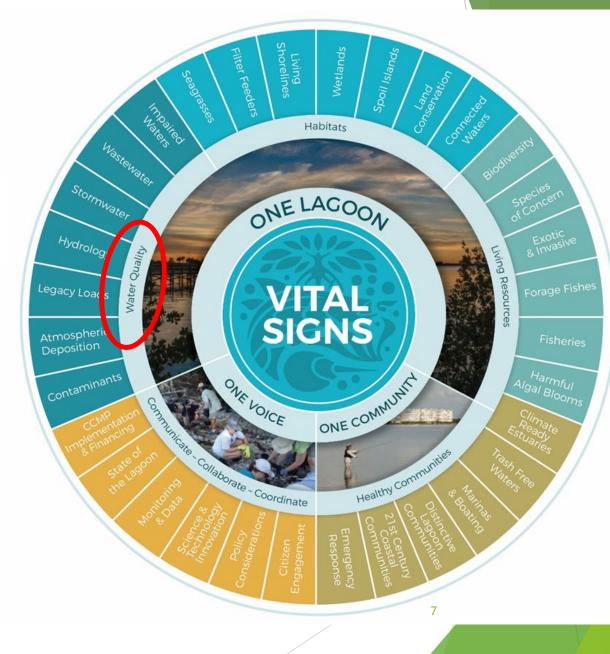
Parkinson et al. 2020 WIS

To help organize and communicate its conservation and management goals the IRL NEP created a 'Vital Signs' wheel

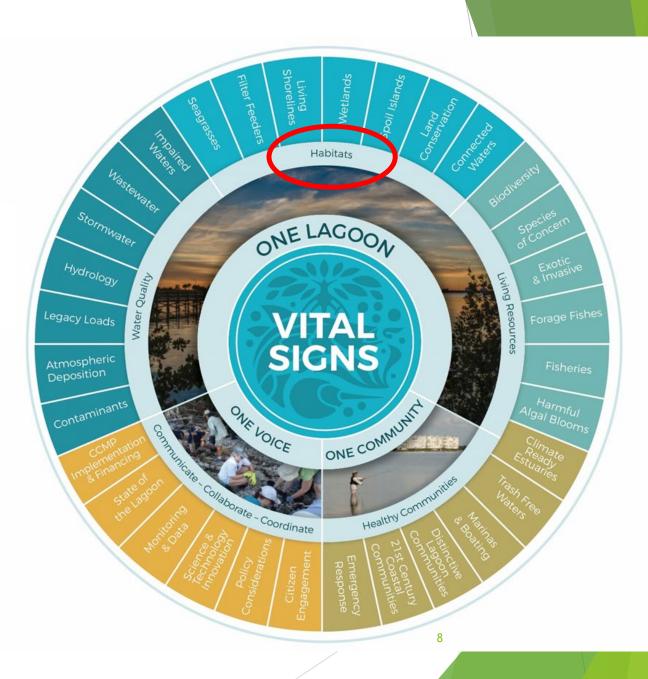




Five vital sign categories 1. Water quality



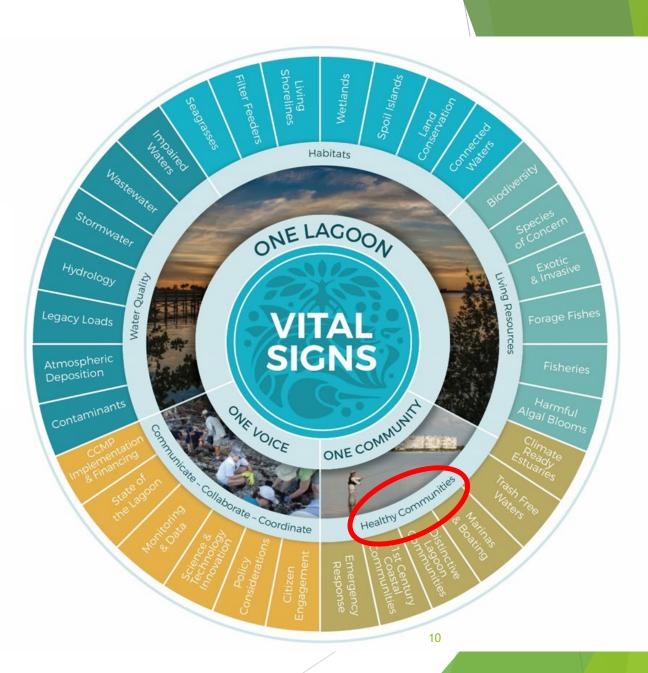
- 1. Water quality
- 2. Habitats



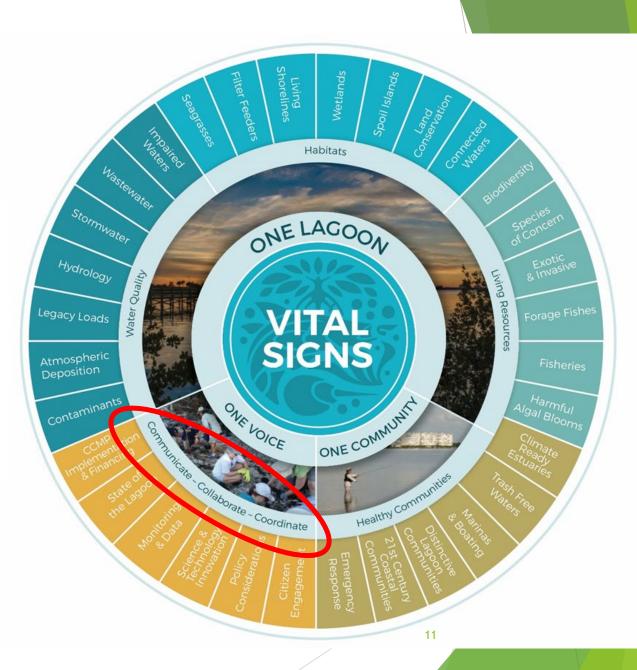
- 1. Water quality
- 2. Habitats
- 3. Living resources



- 1. Water quality
- 2. Habitats
- 3. Living resources
- 4. Healthy communities



- 1. Water quality
- 2. Habitats
- 3. Living resources
- 4. Healthy communities
- 5. Communicate, collaborate, coordinate



32 vital signs were developed to provide guidance towards achieving the goals of each category

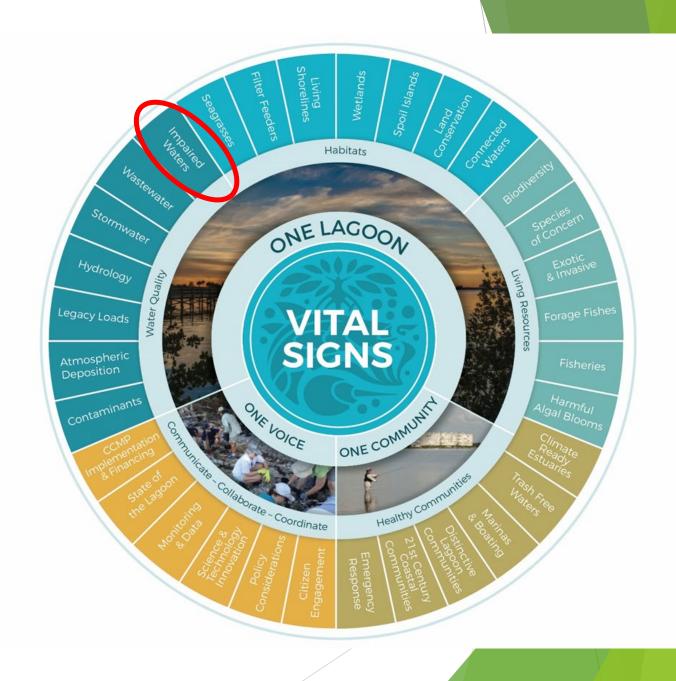


7 vital signs were identified in the water quality category



Impaired Waters focus = <u>track progress</u> in reducing pollutants that cause impairment:

- Total phosphorus
- Total nitrogen
- Chlorophyll-a
- fecal coliform
- metals



Wastewater focus = reduce principle <u>source</u> of pollutants:

- Septic (OSTDS)
- Wastewater treatment plants (WWTP)

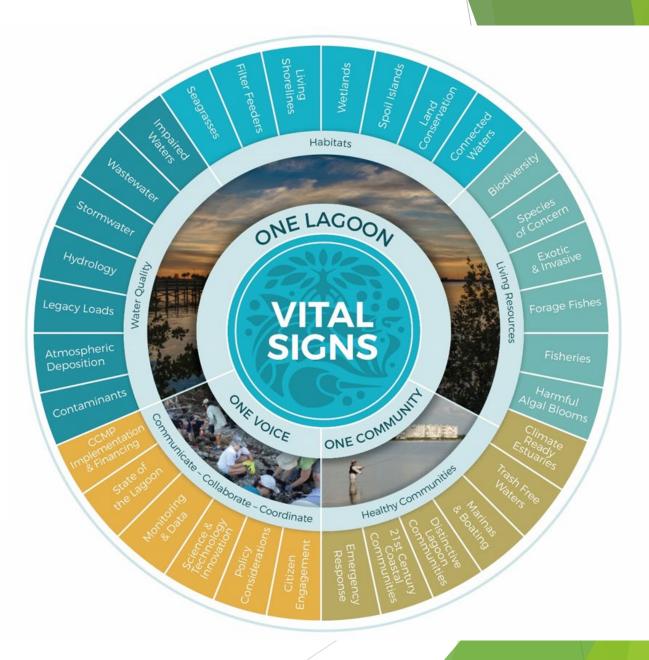


Stormwater Focus = reduce principle <u>source</u> of pollutants:

• Surface water storage and conveyance systems



Climate change will introduce new challenges towards reducing impairment and improving water quality and of course towards the successful completion of the other 25 vital sign goals designed to restore habitat value and ecosystem function.



	Risk Identification - Water Quality Vital Sign: Surface water (storm and fresh)				
Warmer temperature	Clin Changes in precipitation	nate Stressor/Risk Increasing storminess	Acidification	Sea level rise	
Increased pollutant loadings (urban, rural) due to changes in solubility and/or toxicity caused by warmer temperature	Increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events	surface water storage and conveyance infrastructure caused by more	Increased pollutant loadings due to changes in solubility and/or toxicity caused by acidification	Increased pollutant loadings due to higher water table caused by sea level rise	

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Consequence	Spatial extent of impact
1. Low (could adjust, life will go on)	1. Site (bridge, stormwater outflow)
2. Medium	2. Place (wildlife refuge)
3. High (catastrophic, major disruption)	3. Region (watershed)

Likelihood	Time horizon		
1. Low	1. > 10 years		
2. Medium	2. 5-10 years		
3. High (very likely, predictable)	3. Already occurring or < 5 years		

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Minimum = 4 Maximum = 12

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Risk Analysis - Water Quality								
Vital Sign	Climate Stressor	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Wastewater	Warmer temperature	Increased pollutant loadings due to changes in solubility and/or toxicity caused by warmer temperature	1	1	2	2	6	Medium

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44

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			Stress	or					Lev	el of Risk	
Category and Vital Sign	Temp	PPt	Storms	рН	SLR	Sum	Accept	Highe	st Hig	her High	Sum
Water Quality											
Impaired waters (IW)	5	54	57	0	55	171	5	162	4	0	166
Wastewater (WW)	1	10	10	1	10	32	2	30		0	30
Stormwater and surface water (SW)	5	8	8	1	9	31	3	24	2	2	28
Hydrology and hydrodynamics (HH)	3	3	0	0	3	9	0	3	6	0	9
Legacy loads and healthy sediments (LL)	0	0	1	0	0	1	0	0	1	0	1
Atmospheric deposition (AD)	1	1	1	0	0	3	3	0	0	0	0
Sum	15	76	77	2	77	247	13	219	13	2	234
Habitats											
Seagrass (S)	6	16	15	1	14	52	5	47	0	0	47
Living shorelines (LS)	1	1	2	1	2	7	3	0	4	0	4
Wetlands and impounded/altered marshes (W)	3	1	0	0	2	6	5	1	0	0	1
Sum	10	18	17	2	18	65	13	48	4	0	52
Living Resources											
Biodiversity (B)	3	16	11	1	17	48	5	33	10	0	43
Species of concern (SoC)	10	15	18	1	19	63	4	47	12	0	59
Invasive species (InS)	2	15	14	0	14	45	3	14	28	0	42
Commercial and recreational fisheries (CRF)	3	15	19	1	14	52	4	42	6	0	48
Sum	15	45	51	2	47	160	11	103	46	0 ⁴⁵	149
Grand Total	40	139	145	6	142	472	37	370	63	2	435

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Water Quality Temp PPt Storms pH SLR Sum Highest Higher High Sum Impaired waters (IW) 5 54 57 0 55 171 5 162 4 0 166 Wastewater (WW) 1 10 10 1 10 32 2 30 0 30 Stormwater and surface water (SW) 5 8 8 1 9 31 3 24 2 2 28 Hydrology and hydrodynamics (HH) 3 3 0 0 3 9 0 3 6 0 9 Legacy loads and healthy sediments (LL) 0 0 1 1 0 0 3 3 0 0 0 1 1 1 2 277 247 13 219 13 2 234 Habitats				Stress	or					Lev	el of Risk	
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Wastewater (WW) 1 10 10 1 10 32 2 30 0 30 Stormwater and surface water (SW) 5 8 8 1 9 31 3 24 2 2 28 Hydrology and hydrodynamics (HH) 3 3 3 0 0 3 9 0 3 6 0 9 Legacy loads and healthy sediments (LL) 0 0 1 1 0 0 3 3 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 1 1 0 0 1 <t< td=""><td>Water Quality</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>	Water Quality											
Stormwater and surface water (SW) 5 8 8 1 9 31 3 24 2 2 28 Hydrology and hydrodynamics (HH) 3 3 0 0 3 9 0 3 6 0 9 Legacy loads and healthy sediments (LL) 0 0 1 0 0 3 3 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 1 0 0 3 3 0 1 0 0 1 0 0 1 0 0	Impaired waters (IW)	5	54	57	0	55	171	5	162	4	0	166
(SW) 5 8 8 1 9 31 3 24 2 2 28 Hydrology and hydrodynamics (HH) 3 3 0 0 3 9 0 3 6 0 9 Legacy loads and healthy sediments (LL) 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 0 1 1 0 0 1 0 0 0 1 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 <t< td=""><td>Wastewater (WW)</td><td>1</td><td>10</td><td>10</td><td>1</td><td>10</td><td>32</td><td>2</td><td>30</td><td></td><td>0</td><td>30</td></t<>	Wastewater (WW)	1	10	10	1	10	32	2	30		0	30
(H) 3 3 0 0 3 9 0 3 6 0 9 Legacy loads and healthy sediments (LL) 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 0 1 1 0 0 3 3 0 0 0 0 0 0 1 1 1 0 0 3 3 0 0 0 0 0 0 1 1 0 0 1		5	8	8	1	9	31	3	24	2	2	28
sediments (LL) 0 0 1 0 0 1 0 0 1 0 0 1 Atmospheric deposition (AD) 1 1 1 1 0 0 3 3 0 0 0 0 Sum 15 76 77 2 77 247 13 219 13 2 234 Habitats		3	3	0	0	3	9	0	3	6	0	9
Sum 15 76 77 2 77 247 13 219 13 2 234 Habitats		0	0	1	0	0	1	0	0	1	0	1
Habitats Image: Constraint of the second of th	Atmospheric deposition (AD)	1	1	1	0	0	3	3	0 0 0		0	0
Seagrass (S) 6 16 15 1 14 52 5 47 0 0 47 Living shorelines (LS) 1 1 2 1 2 7 3 0 4 0 4 Wetlands and	Sum	15	76	77	2	77	247	13	219 13 2		2	234
Living shorelines (LS) 1 1 2 1 2 7 3 0 4 0 4 Wetlands and impounded/altered marshes (W) 3 1 0 0 2 6 5 1 0 0 1 Sum 10 18 17 2 18 65 13 48 4 0 52 Living Resources Joint Mark	Habitats											
Wetlands and impounded/altered marshes (W) 3 1 0 0 2 6 5 1 0 0 1 Sum 10 18 17 2 18 65 13 48 4 0 52 Living Resources Image: Second s	Seagrass (S)	6	16	15	1	14	52	5	47	0	0	47
impounded/altered marshes (W) 3 1 0 0 2 6 5 1 0 0 1 Sum 10 18 17 2 18 65 13 48 4 0 52 Living Resources 10 18 17 2 18 65 13 48 4 0 52 Biodiversity (B) 3 16 11 1 17 48 5 33 10 0 43 Species of concern (SoC) 10 15 18 1 19 63 4 47 12 0 59 Invasive species (InS) 2 15 14 0 14 45 3 14 28 0 42 Commercial and recreational fisheries (CRF) 3 15 19 1 14 52 4 42 6 0 48 Sum 15 45 51 2 47 10 14 051 149	Living shorelines (LS)	1	1	2	1	2	7	3	0	4	0	4
Living Resources Image: Section of the sectin of the section of the section of the section of the section of t	impounded/altered marshes	3	1	0	0	2	6	5	1 0 0		1	
Biodiversity (B) 3 16 11 1 17 48 5 33 10 0 43 Species of concern (SoC) 10 15 18 1 19 63 4 47 12 0 59 Invasive species (InS) 2 15 14 0 14 45 3 14 28 0 42 Commercial and recreational fisheries (CRF) 3 15 19 1 14 52 4 42 6 0 48 Sum 15 45 51 2 47 160 11 149 46 0 ⁵¹ 149	Sum	10	18	17	2	18	65	13	48	4	0	52
Species of concern (SoC) 10 15 18 1 19 63 4 47 12 0 59 Invasive species (InS) 2 15 14 0 14 45 3 14 28 0 42 Commercial and recreational fisheries (CRF) 3 15 19 1 14 52 4 42 6 0 48 Sum 15 45 51 2 47 46 0 ⁵¹ 149	Living Resources											
Invasive species (InS) 2 15 14 0 14 45 3 14 28 0 42 Commercial and recreational fisheries (CRF) 3 15 19 1 14 52 4 42 6 0 48 Sum 15 45 51 2 47 46 0 14 149	Biodiversity (B)	3	16	11	1	17	48	5	33 10 0		0	43
Commercial and recreational fisheries (CRF) 3 15 19 1 14 52 4 42 6 0 48 Sum 15 45 51 2 47 26 11 103 46 0 ⁵¹ 149	Species of concern (SoC)	10	15	18	1	19	63	4	47 12		0	59
fisheries (CRF) 3 15 19 1 14 52 4 42 6 0 48 Sum 15 45 51 2 47 103 46 0 51 149	Invasive species (InS)	2	15	14	0	14	45	3	3 14 28		0	42
		3	15	19	1	14	52	4	42	6	-	48
Grand Total 40 139 145 6 142 472 37 370 63 2 435	Sum	15	45	51	2	47	269	11	103	46	0 ⁵¹	149
	Grand Total	40	139	145	6	142	472	37	370	63	2	435

			Stress	or					Lev	el of Risk	
Category and Vital Sign	Temp	PPt	Storms	рН	SLR	Sum	Accept	Highe	st Hig	her High	Sum
Water Quality											
Impaired waters (IW)	5	54	57	0	55	171	5	162	4	0	166
Wastewater (WW)	1	10	10	5()%	32	2	30		0	30
Stormwater and surface water (SW)	5	8	8	1	9	31	3	24	2	2	28
Hydrology and hydrodynamics (HH)	3	3	0	0	3	9	0	3	6	0	9
Legacy loads and healthy sediments (LL)	0	0	1	0	0	1	0	0	1	0	1
Atmospheric deposition (AD)	1	1	1	0	0	3	3	0	0	0	0
Sum	15	76	77	2	77	247	13	219	13	2	234
Habitats											
Seagrass (S)	6	16	15	1	14	52	5	47	0	0	47
Living shorelines (LS)	1	1	2	1	2	7	3	0	4	0	4
Wetlands and impounded/altered marshes (W)	3	1	0	0	2	6	5	1	0	0	1
Sum	10	18	17	2	18	65	13	48	4	0	52
Living Resources											
Biodiversity (B)	3	16	11	1	17	48	5	33	10	0	43
Species of concern (SoC)	10	15	18	1	19	63	4	47	12	0	59
Invasive species (InS)	2	15	14	0	14	45	3	14	28	0	42
Commercial and recreational fisheries (CRF)	3	15	19	1	14	52	4	42	6	0	48
Sum	15	45	51	2	47	160	11	103	46	0 ⁵²	149
Grand Total	40	139	145	6	142	472	37	370	63	2	435

			Stress	or					Level	of Risk	
Category and Vital Sign	Temp	PPt	Storms	рН	SLR	Sum	Accept	Highe	est Highe	er High	Sum
Water Quality											
Impaired waters (IW)	5	54	57	0	55	171	5	162	4	0	166
Wastewater (WW)	1	10	10	5()%	32	2	30	58%	0	30
Stormwater and surface water (SW)	5	8	8	1	9	31	3	24	2	2	28
Hydrology and hydrodynamics (HH)	3	3	0	0	3	9	0	3	6	0	9
Legacy loads and healthy sediments (LL)	0	0	1	0	0	1	0	0	1	0	1
Atmospheric deposition (AD)	1	1	1	0	0	3	3	0	0	0	0
Sum	15	76	77	2	77	247	13	219	13	2	234
Habitats											
Seagrass (S)	6	16	15	1	14	52	5	47	0	0	47
Living shorelines (LS)	1	1	2	1	2	7	3	0	4	0	4
Wetlands and impounded/altered marshes (W)	3	1	0	0	2	6	5	1	0	0	1
Sum	10	18	17	2	18	65	13	48	4	0	52
Living Resources											
Biodiversity (B)	3	16	11	1	17	48	5	33	10	0	43
Species of concern (SoC)	10	15	18	1	19	63	4	47	12	0	59
Invasive species (InS)	2	15	14	0	14	45	3	14	28	0	42
Commercial and recreational fisheries (CRF)	3	15	19	1	14	52	4	42	6	0	48
Sum	15	45	51	2	47	160	11	103	46	0 ⁵³	149
Grand Total	40	139	145	6	142	472	37	370	63	2	435

			Stress	or					Lev	el of Risk	
Category and Vital Sign	Temp	PPt	Storms	рН	SLR	Sum	Accept	Highe	st Hig	her High	Sum
Water Quality											
Impaired waters (IW)	5	54	57	0	55	171	97%	162	4	0	166
Wastewater (WW)	1	10	10	1	10	32	71/0	30		0	30
Stormwater and surface water (SW)	5	8	8	1	9	31	3	24	2	2	28
Hydrology and hydrodynamics (HH)	3	3	0	0	3	9	0	3	6	0	9
Legacy loads and healthy sediments (LL)	0	0	1	0	0	1	0	0	1	0	1
Atmospheric deposition (AD)	1	1	1	0	0	3	3	0	0	0	0
Sum	15	76	77	2	77	247	13	219	13	2	234
Habitats											
Seagrass (S)	6	16	15	1	14	52	5	47	0	0	47
Living shorelines (LS)	1	1	2	1	2	7	3	0	4	0	4
Wetlands and											
impounded/altered marshes	3	1	0	0	2	6	5	1	0	0	1
(W)											
Sum	10	18	17	2	18	65	13	48	4	0	52
Living Resources											
Biodiversity (B)	3	16	11	1	17	48	5	33	10	0	43
Species of concern (SoC)	10	15	18	1	19	63	4	47	12	0	59
Invasive species (InS)	2	15	14	0	14	45	3	14	28	0	42
Commercial and recreational fisheries (CRF)	3	15	19	1	14	52	4	42	6	0	48
Sum	15	45	51	2	47	160	11	103	46	0 ⁵⁴	149
Grand Total	40	139	145	6	142	472	37	370	63	2	435

Overall Project Goal

- 1. Conduct a risk assessment of IRL NEP mission to climate change
- 2. Prioritize risks
- 3. Formulate action plans to reduce risks



Stressor	Adaptation Action
	Reduce pollutant loadings from WWTP durng high rainfall events
PPt	Reduce pollutant loadings from OSTDS during high rainfall events
FFL	Reduce pollutant loadings from surface water storage and conveyance infrastructure
	during high rainfall events
	Reduce pollutant loadings from WWTP due to more frequent and intense storms
Storms	Reduce pollutant loadings from OSTDS due to more frequent and intense storms
5101115	Reduce pollutant loadings from surface water storage and conveyance infrastructure
	due to more frequent and intense storms
	Reduce pollutant loadings from WWTP caused by rising water table and sea level
	(inundation, erosion)
SLR	Reduce pollutant loadings from OSTDS caused by rising water table and sea level
SLR	(inundation, erosion)
	Reduce pollutant loadings from surface water storage and conveyance infrastructure
Parkinson et al. 2020 WIS	caused by rising water table and sea level (inundation, erosion) 56

Stressor	Adaptation Action
	Reduce pollutant loadings from WWTP durng high rainfall events
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	Reduce pollutant loadings from WWTP caused by rising water table and sea level
	(inundation, erosion)
SLR	Reduce pollutant loadings from OSTDS caused by rising water table and sea level
JEN	(inundation, erosion)
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Parkinson et al. 2020 WIS	caused by rising water table and sea level (inundation, erosion) 57

Stressor	Adaptation Action
	Reduce pollutant loadings from WWTP durng high rainfall events
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	Reduce pollutant loadings from WWTP caused by rising water table and sea level
	(inundation, erosion)
SLR	Reduce pollutant loadings from OSTDS caused by rising water table and sea level
JLN	(inundation, erosion)
	Reduce pollutant loadings from surface water storage and conveyance infrastructure
Parkinson et al. 2020 WIS	caused by rising water table and sea level (inundation, erosion) 58

Stressor	Adaptation Action
*	Reduce pollutant loadings from WWTP durng high rainfall events
PPt	Reduce pollutant loadings from OSTDS during high rainfall events
rri	Reduce pollutant loadings from surface water storage and conveyance infrastructure
	during high rainfall events
	Reduce pollutant loadings from WWTP due to more frequent and intense storms
Storms	Reduce pollutant loadings from OSTDS due to more frequent and intense storms
5101115	Reduce pollutant loadings from surface water storage and conveyance infrastructure
	due to more frequent and intense storms
	Reduce pollutant loadings from WWTP caused by rising water table and sea level
	(inundation, erosion)
SLR	Reduce pollutant loadings from OSTDS caused by rising water table and sea level
JLN	(inundation, erosion)
	Reduce pollutant loadings from surface water storage and conveyance infrastructure
Parkinson et al. 2020 WIS	caused by rising water table and sea level (inundation, erosion) 59

Stressor	Adaptation Action
	Reduce pollutant loadings from WWTP durng high rainfall events
PPt 😽	Reduce pollutant loadings from OSTDS during high rainfall events
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Storms	Reduce pollutant loadings from OSTDS due to more frequent and intense storms
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SLR	Reduce pollutant loadings from OSTDS caused by rising water table and sea level
JLN	(inundation, erosion)
	Reduce pollutant loadings from surface water storage and conveyance infrastructure
Parkinson et al. 2020 WIS	caused by rising water table and sea level (inundation, erosion) 60

Stressor	Adaptation Action
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JLN	(inundation, erosion)
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Parkinson et al. 2020 WIS	caused by rising water table and sea level (inundation, erosion) 61

Stressor	Adaptation Action
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Stressor	Adaptation Action
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To achieve the goals of the nine Adaptation Actions, nine Action Plans are recommended, each consisting of the following five tasks to be completed at the appropriate level of organizational governance



- 1. Construct a georeferenced map of all systems, including (invert)elevations, proximity to groundwater table and IRL shoreline.
- 2. Evaluate integrity of systems (age, service history, present and future investment).
- 3. Evaluate system vulnerability associated with three most significant climate change stressors (i.e., ppt, storms, SLR).
- 4. Prioritize risks to WWTP, OSTDS, SWSC systems based upon 2 and 3.
- 5. Prepare a Climate Change Adaptation Strategy (CCAS) containing a comprehensive set of prioritized goals and objectives to mitigate the risks to each system.

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- 5. Prepare a Climate Change Adaptation Strategy (CCAS) containing a comprehensive set of prioritized goals and objectives to mitigate the risks to each system.

Final Step: Implementation and monitoring strategy

Elevated pollutant loadings caused by climate change will likely complicate the ability of existing BMAPs to meet their respective TMDL targets.



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Elevated pollutant loadings caused climate change will likely complicate the ability of existing BMAPs to meet their respective TMDL targets.

Hence, it appears logical to incorporate the nine actions plans and associated Climate Change Adaptation Strategies described herein into existing BMAP/TMDL programs operating within the IRL watershed.

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Final Step: Implementation and monitoring strategy

Elevated pollutant loadings caused climate change will likely complicate the ability of existing BMAPs to meet their respective TMDL targets.

Hence, it appears logical to incorporate the nine actions plans and associated Climate Change Adaptation Strategies described herein into existing BMAP/TMDL programs operating within the IRL watershed.

The program already has an established leadership hierarchy, partnership network, funding stream, and reporting / monitoring protocol.

The Bottom Line

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To reduce IRL water quality impairment caused by both historical land use changes and future land use and climate change, we must reduce the input of nutrient pollution (i.e., nitrogen and phosphorous) from OSTDS, WWTP, and SWSC infrastructure.

The Bottom Line

To reduce IRL water quality impairment caused by both historical land use changes and future land use and climate change, we must reduce the input of nutrient pollution (i.e., nitrogen and phosphorous) from OSTDS, WWTP, and SWSC infrastructure.

This will improve water quality, reduce impairment, and stimulate the recovery of a more resilient, climate-ready estuary.

Adaptation Actions To Reduce Impairment of Indian River Lagoon Water Quality Caused by Climate Change

Presented to: UF Water Institute Symposium February 25, 2020 Gainesville, Florida

By: Randall W. Parkinson, Ph.D., P.G., Sea Level Solutions Center Institute of Environment Florida International University Miami, Florida







