Application of the Recovery Potential Screening Tool in the Matagorda Bay Watershed

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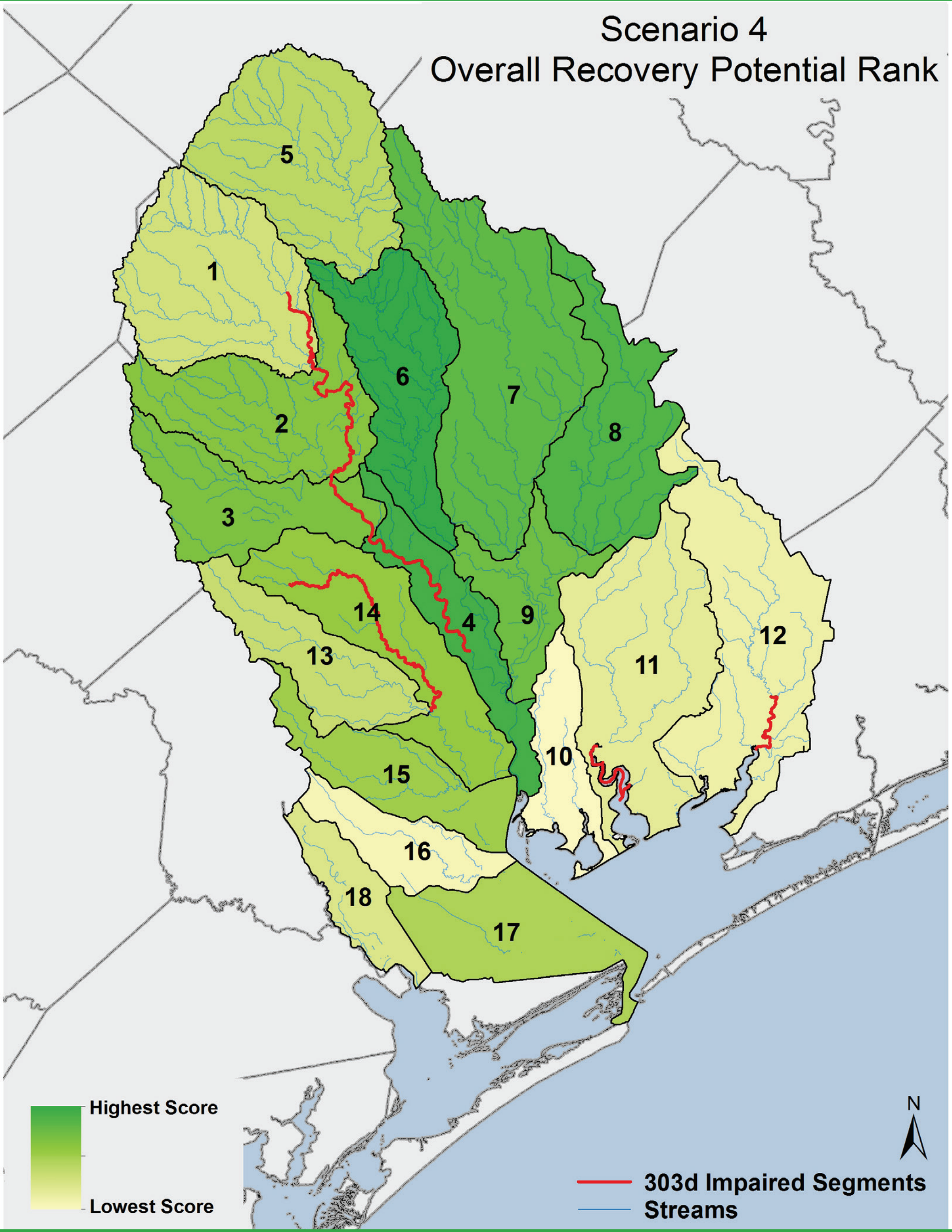

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Introduction

The State of Texas currently contains 568 water bodies considered impaired due to excessive pollutant loading. Of these, approximately 48% are impaired due to elevated levels of fecal indicator bacteria from animals, birds and humans. Once impaired, efforts to restore water quality must be undertaken. This large number of bacteria impairments leaves the State with a sizable task ahead and presents a range of restoration challenges. Restoring all of these impaired water bodies is costly and resource intensive, thus prioritizing future water quality restoration efforts is a means to efficiently allocate available resources and achieve timely restoration results.

The U.S. Environmental Protection Agency (EPA) developed the Recovery Potential Screening (RPS) tool to help prioritize water body restoration planning efforts (Norton et al. 2009). Built as a technical aid for states and government agencies, the RPS tool provides a systematic approach for comparing the relative restorability of water bodies. When employed and supplied with sufficient data, this tool can aid groups and entities considering restoration efforts determine which water bodies have the highest likelihood of successful water quality restoration based on characteristics of the local watershed (U.S. EPA 2014).

RPS compares the relative ability of water bodies or watersheds to recover from an impairment of choice by measuring several ecological, stressor, and social indicators that are associated with the likelihood of achieving restorative success. These indicators are selected from a list of available indicators based on what is appropriate for the water bodies being screened, the availability of data of quality, and the goals of the planned restoration project. The tool calculates a Recovery Potential Integrated (RPI) score by combining the weight of these indicators to establish an overall score. This RPI score in turn ranks the screened watersheds based on their potential restorability. RPS does not target any water body as a definitive restorable or un-restorable water body. Rather, it compares water bodies relative to each other and assesses their restorability based on information provided (U.S. EPA 2014).

This tool is not widely utilized in Texas and its applicability to the state is uncertain due to the limited availability of data in many rural areas. A project to evaluate bacteria impaired water bodies in the Matagorda Bay watershed and devise a plan to restore these impaired waters is currently underway and is being used as a testing platform for the RPS tool. The intent is to apply this tool to the impaired water bodies in the project area and assess its utility as a feasible tool to prioritize future restoration. This report summarizes the application of the tool, briefly describes the study area, discusses available inputs utilized, results from the tool, and the utility of its output.

RPS Tool Methodology

RPS uses a "Seven Step Process" to compare water body restorability within the evaluated area. The RPS tool considers a suite of several ecological, stressor and social context indicators that factor into the overall likelihood that a stream can be restored. In general terms, these indicators broadly encompass factors with a strong connection to a water body's restorability. Ecological indicators focus on the physical nature of the stream and watershed and their ability to return to a natural state. Stressor indicators reflect adverse impacts occurring in the watershed such as hydrologic modification, pollutant loading and watershed disturbances. Social context indicators concentrate on factors that do not directly influence the condition of the watershed, but do so indirectly. These include factors such as local stakeholder involvement, available restoration incentives, the socio-economic status of watershed residents and entities among others (U.S. EPA 2014). A complete list of potential RPS metrics is included in Appendix A. Indicators utilized in this application of the tool are discussed later in Step 2 of this methodology. This section of the report describes each step of RPS tool application in general terms.

Step 1: Define the Scope

The first step in the process establishes the framework for applying the RPS tool. This step includes defining the geographic area of interest, defining the targeted units of the assessment, identifying the purpose and participants of the screening and defining the types of expected outputs.

Step 2: Design the Analytical Approach

In the second step of this process, the analytical approach to the screening is designed. This includes establishing identity numbers for each of the targeted units being evaluated in the screening, selecting potentially appropriate candidate indicators, gathering needed datasets, defining indicator measures and finally reviewing and refining indicators selected.

Step 3: Measure the Indicators

Following data collection and final indicator selection, indicator measurement began. This process includes establishing basic baseline data for the project area, compiling raw indicator data values, aligning these indicator values and performing a quality check to ensure that the prepared data spreadsheets are properly formatted and calculating recovery indices properly.

Step 4: Calculate Summary Scores

Following data aggregation and organization conducted in Step 3, the indicators selected for inclusion and their accompanying datasets are inputted into the RPS tool. Data are used by the RPS tool to produce relative restorability rankings of water bodies in the target area. Within the tool, individual indicators are selected for use within a single run of the tool. Adding indicators to the assessment is as easy as selecting them and rerunning the tool. This capability enables the influences of single factors to be evaluated quickly and ultimately identify the indicators that best represent the restorative potential of the selected area.

The RPS tool performs a series of calculations automatically to produce the restoration potential index; these include normalizing the data and calculating separate summary indices for ecological, stressor and social indicators and a final calculation to produce an integrated recovery potential index (RPI). Higher individual scores for ecological and social indicators indicate better restoration potential while lower stressor scores make this suggestion. The developed RPI considers these three indices to produce an overall RPI score. Increased restoration potential is denoted by a higher RPI score.

Step 5: Compare Relative Recovery Potential Results

Comparing RPS tool outputs and presenting the data in a user friendly manner is the goal of Step 5. In this step, results from Step 4 are presented in 3 separate forms to aid interpretation of the data. Rank-ordering is the first and simplest approach. It is based on the numeric recovery potential score and the water body with the highest recovery potential is ranked first and the lowest potential is ranked last. This method is effective, but provides little information about the relative restorability between subbasins. Three-dimensional bubble plotting is a graphical means to compare results that illustrates the recovery potential of each subbasin for each of the 3 recovery indicators. Essentially, subbasins with the highest restoration potential will be represented by a circle of varying size in the upper-left quadrant of the plot; larger circles have higher restoration potential due to social indices (Figure 1). Color can also be added to the plot to illustrate key water bodies within the assessment. Mapping is the third, and perhaps most intuitive method to display results as it provides a geographic reference to the subbasins evaluated and color codes restoration potential for each subbasin.

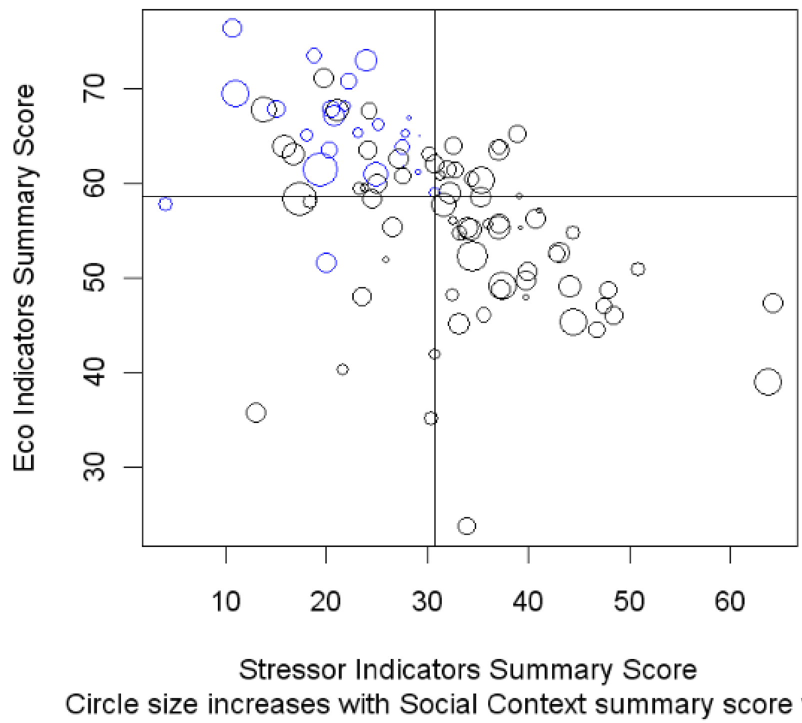

Figure 1. Example bubble plot illustrating relative ecological, stressor and social summary scores from the RPS tool

Step 6: Refine the Assessment

This step in the evaluation process provides the user a chance to reevaluate the indicators used, add additional data or indicators, and adjust the overall goal of RPS tool application based upon information gleaned through the assessment. Refinements can include changes in key questions asked, the desired type of output or even a decision to aggregate various screening runs. Regardless, this is done at the discretion of the RPS tool user.

Step 7: Use of RPS Results

Uses of RPS tool results can vary widely. As built, the tool was developed to compare the restoration capacity of impaired waters and prioritize these waters for future development of total maximum daily loads. The uses of the tool extend beyond this purpose and can include river basin plan development, healthy watershed planning, targeting restoration efforts, and fisheries management among others.

Results

The RPS tool was applied in the Matagorda Bay watershed along the Texas Gulf Coast to evaluate water quality restoration potential among water bodies impaired for elevated levels of fecal indicator bacteria within this area. The results presented here document the results of this evaluation.

Define the Scope

The Matagorda Bay watershed and the bacterially impaired water bodies it contains are the focus area for this project. This watershed encompasses three major river basins along the central coastline of Texas including the Colorado-Lavaca Coastal, Lavaca River and Lavaca-Guadalupe Coastal basins (Figure 2). Additionally, 9 smaller bays are encompassed within this larger bay system as well. Inland, the watershed area contains all of Jackson County and parts of Calhoun, Colorado, DeWitt, Fayette, Gonzales, Lavaca, Matagorda, Victoria and Wharton counties. It covers approximately 2,762,713 acres of mostly rural land that is dominated by pasture and rangeland, cropland, forests and wetlands. These areas are primarily used for growing crops, producing livestock, and serve as wildlife habitat. Developed land, open water and barren land make up the remaining land uses. A more complete description of the watershed can be found in Gregory et al. (2014).

Within the Matagorda Bay watershed, approximately 2,205.1 miles of intermittent and perennial streams exist while 516.4 are assessed bi-annually by the state. Of these, 109.7 miles of Arenosa Creek, Lavaca River Above Tidal and Tres Palacios Creek Tidal are impaired due to elevated bacteria levels. The Matagorda Bay complex encompasses 284,002 acres. Of this, 4,493 acres of Upper Carancahua Bay is also considered impaired due to elevated levels of bacteria (Table 1). Collectively, these four impaired water bodies are the specific focus area for RPS tool application.

Initially, RPS tool application was planned for impaired water bodies and their watersheds only. However, the rural nature of these watersheds and limited data availability at subbasin scales led to its application on the entire Matagorda Bay watershed area simultaneously. This approach also allowed RPS tool output to be compared between impaired and unimpaired subbasins. Essentially, the unimpaired subbasins served as reference points throughout the assessment.

To accomplish this, the watershed was divided into smaller watershed subbasins. ArcMap 10.1 software (Environmental Systems Research Institute) was utilized to define and depict watershed subbasins based on 10 digit Hydrologic Unit Codes (HUC 10) established by the U.S. Geological Survey (USGS) and Natural Resource Conservation Service (NRCS). This subdivided the Matagorda Bay watershed area into 18 similar sized areas (Figure 3). Boundaries of these subbasins are determined based on the surface hydrology of the area. In some cases, the outlet of one subbasin serves as an input to the downstream subbasin. Initially, each subbasin was treated independently; however, to compare impaired water bodies, subbasins 1, 2, 3, and 4 were aggregated to evaluate the collective restoration potential of the Lavaca River Above Tidal.

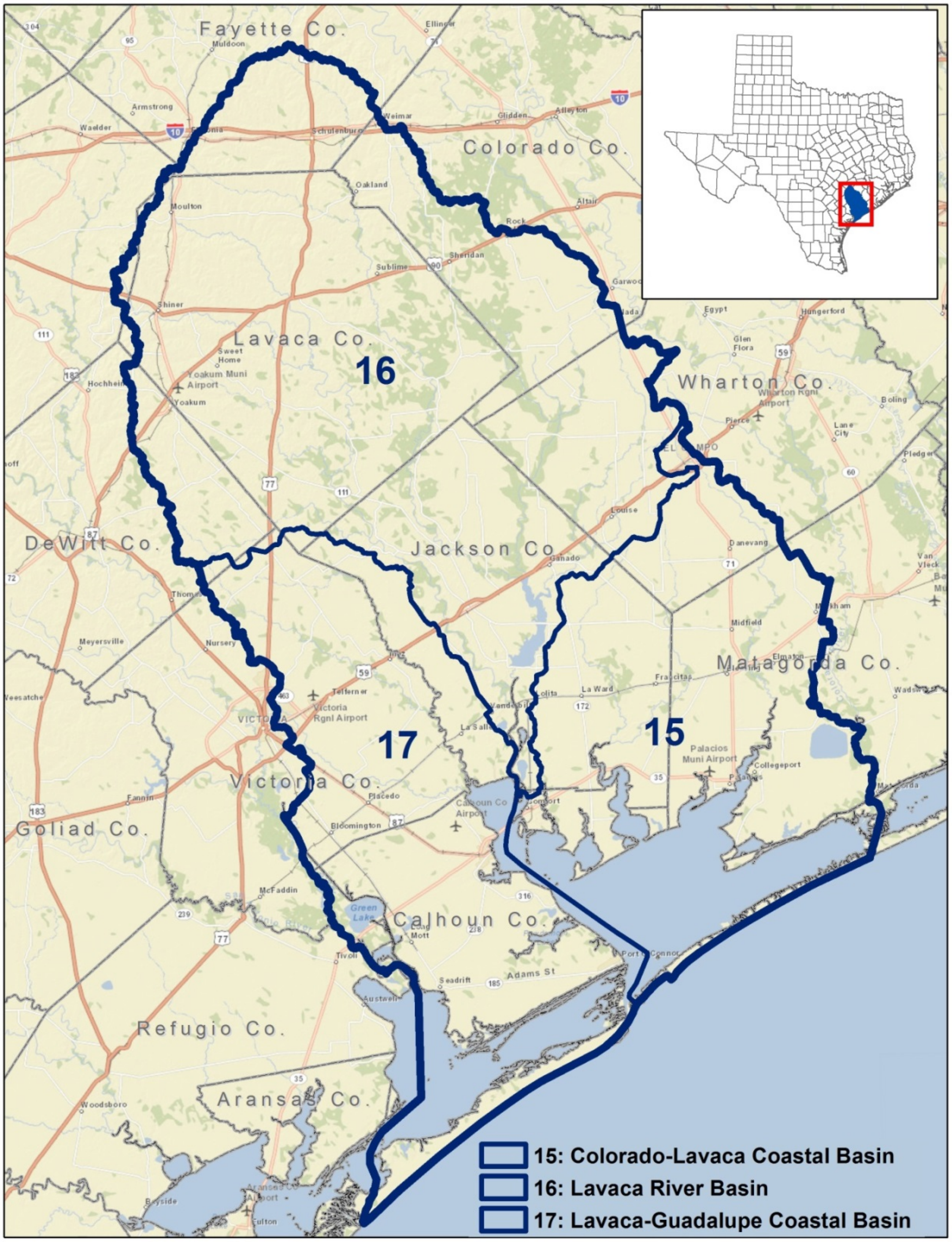

Figure 2. Major river basins of the Matagorda Bay watershed

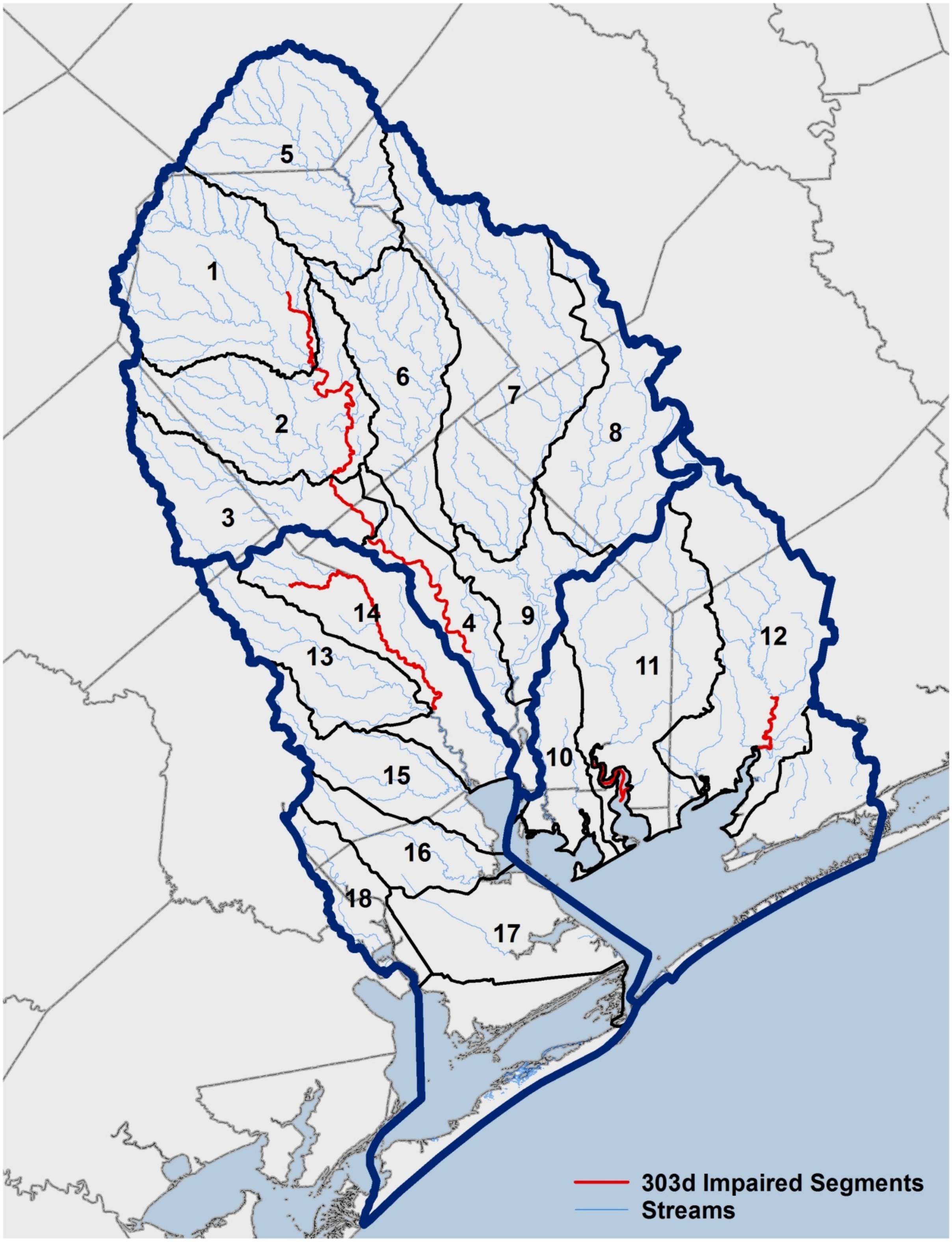

Figure 3. Project area map showing watershed subbasins delineated and assigned IDs

In this project, application of the RPS tool is primarily an assessment of its capabilities. Thus, the participants were limited to project staff and agency advisors. The expected output from the tool is a refined recovery potential ranking for each of the watershed subbasins and impaired water bodies in the watershed indicating their relative ability to be restored as compared to the other watershed subbasins and impaired water bodies.

Designed Approach

Watershed subbasins (USGS HUC 10 watersheds) were assigned one or two-digit ID numbers for ease of labeling. Table 1 lists these ID numbers along with the USGS 10-digit HUC and acreages for each subbasin. Potential indicators were selected using the list of "candidate recovery potential indicators" (Appendix A) and the "Selection and Weighting Worksheet for Recovery Potential Indicators." Using knowledge of the project team, the worksheet was filled out to identify candidate indicators that are relevant to the project area and are likely to provide useful input to the RPS tool (Appendix B).

Table 1. Basin watershed ID with corresponding HUC 10 and impairment information

Watershed Subbasin ID Number	HUC 10 ID Number	HUC 10 Subbasin Name	Subbasin Acres	Bacteria Impaired Water body?
1	1210010101	Rocky Creek – Lavaca River	198,400	Yes – Lavaca River Above Tidal
2	1210010102	Clarks Creek - Lavaca River	166,300	
3	1210010103	Little Brushy Creek – Lavaca River	123,151	
4	1210010104	Keller Branch – Lavaca River	94,510	
5	1210010201	Headwaters Navidad River	212,173	No
6	1210010202	Ragsdale Creek – Lavaca River	150,328	No
7	1210010203	West Sandy Creek – Sandy Creek	295,797	No
8	1210010204	West Mustang Creek	156,194	No
9	1210010205	Mustang Creek – Navidad River	82,541	No
10	1210040101	Cox Creek	69,546	No
11	1210040102	East Carancahua Creek	220,252	Yes – Carancahua Bay
12	1210040103	Tres Palacios Creek	235,056	Yes – Tres Palacios Creek Tidal
13	1210040201	Garcitas Creek	104,283	No
14	1210040202	Arenosa Creek	158,576	Yes – Arenosa Creek
15	1210040203	Placedo Creek	104,771	No
16	1210040204	Chocolate Bayou	73,378	No
17	1210040205	Powderhorn Lake	132,030	No
18	1210040301	Black Bayou – Green Lake	60,957	No

Note: color coding matches highlight colors in RPS tool bubble plot outputs

Following initial indicator selection, data identification and gathering ensued. Generally, data gathered focused on geospatial data and water quality monitoring data. Geospatial information such as city limits, road locations, county boundaries, topography, land use/land cover maps, flow lines, water monitoring stations, wastewater outfalls, impaired river segments, and U.S. Census information were gathered and integrated into a working GIS database of the watershed. Water quality monitoring data was also gathered and stored electronically and was linked to the watershed GIS. A complete list of the data sources gathered and their sources is included in Appendix C.

Once data gathering was complete, a review of the available data was undertaken. Determining the uniformity of data across the entire watershed and exploring the way in which indicators are quantified within these data sets was the goal of this exercise. Special consideration was given to ensure that utilized data sets were consistent across the project area and will produce consistent results across the entire watershed. Following this assessment, the list of candidate indicators initially chosen was revisited (Appendix B) to determine if available data supported their use. Ultimately, 14 indicators relative to the projects purpose were selected. Table 2 lists the indicators selected for use in the RPS assessment of the watershed. Definitions of each indicator are provided in Appendix D and describe what each indicator measures and how it is calculated.

Table 2. Indicators selected for use in the initial application of the RPS tool in the Matagorda Bay watershed

Ecological Indicators	**Stressor Indicators**	**Social Indicators**
Stream Density	% Agricultural Land Use	# of Recreational Resources
% of Natural Cover	% Impervious Cover	Population
% Forests	% Urban	
% Wetlands	Road Density	
% Woody Vegetation	# of WWTF Outfall Permits	
% Unimpaired Stream Length		
Subbasin Size (Acres)		

Measuring Indicators

Baseline data for the watershed was established and included subbasin IDs, stream names, stream length, subbasin size, and subbasin total stream length. These values serve as a basis for calculating other indicator values utilized in the assessment. To calculate these values, the watershed GIS and database were often queried to produce needed values such as percentages of land use/land cover areas, road density, stream density and other similar values. Raw data for each indicator type is shown in Tables 3

(Ecological), 4 (Stressor), and 5 (Social). Raw data were compiled into a single table and aligned with each corresponding subbasin ID and indicator category. Finally, an extensive review of the data and the compiled data table was completed as a quality assurance check.

Table 3. Raw data for initial ecological indicators used in Scenario 1

Subbasin ID	*Stream Density	% Natural Cover	% Forest Area	% Wetland Area	% Woody Vegetation	% of Streams Unimpaired	Subbasin Size Total (Acres)
1	0.0005	28.17	8.08	3.85	25.67	99.84	198,400
2	0.0005	53.27	28.68	7.89	49.50	99.88	166,300
3	0.0003	60.56	31.32	7.65	56.36	99.90	123,151
4	0.0003	42.47	14.79	12.85	34.22	99.73	94,510
5	0.0005	31.18	11.93	7.42	29.30	100.00	212,173
6	0.0005	71.85	42.51	8.66	67.80	100.00	150,328
7	0.0004	45.01	24.82	5.82	42.30	100.00	295,797
8	0.0004	12.51	3.81	4.97	11.31	100.00	156,194
9	0.0004	25.94	10.15	7.23	21.37	100.00	82,541
10	0.0002	34.62	1.54	8.77	22.02	100.00	69,546
11	0.0002	22.31	7.15	4.89	16.20	100.00	220,252
12	0.0003	13.85	2.38	5.13	9.79	99.64	235,056
13	0.0003	36.34	12.79	3.59	30.75	99.92	104,283
14	0.0003	25.20	4.69	7.21	17.46	99.86	158,576
15	0.0003	15.27	1.80	3.06	11.44	100.00	104,771
16	0.0003	8.11	0.90	1.73	5.38	100.00	73,378
17	0.0001	46.26	0.98	25.04	19.83	100.00	132,030
18	0.0002	51.85	1.72	40.06	19.29	100.00	60,957

*stream density calculated by dividing stream miles in subbasin by subbasin size

Table 4. Raw data for stressor indicators used in Scenario 1

Subbasin ID	% Agriculture Area	% Impervious Cover	% Urban Area	*Road Density	# of Stormwater and Wastewater Outfall Permits
1	65.04	0.25	0.85	0.0011	3
2	41.09	0.20	0.87	0.0008	1
3	34.92	0.03	0.16	0.0005	0
4	50.13	0.58	1.98	0.0007	3
5	62.11	0.22	0.80	0.0011	4
6	23.52	0.01	0.11	0.0005	0
7	51.69	0.01	0.10	0.0004	1
8	82.96	0.06	0.36	0.0009	3
9	68.99	0.16	1.01	0.0009	2
10	57.62	1.47	2.76	0.0004	29
11	74.22	0.01	0.20	0.0007	12
12	79.29	0.40	1.51	0.0009	9
13	58.53	0.21	0.60	0.0007	2
14	70.96	0.08	0.23	0.0006	0
15	75.42	2.36	4.25	0.0008	2
16	71.32	0.91	2.32	0.0010	2
17	48.13	0.50	1.51	0.0004	9
18	39.19	1.10	2.54	0.0005	22

*Road density calculated by dividing length of roadway in subbasin by subbasin size

Table 5. Raw data for social indicators used in Scenario 1

Subbasin ID	Recreational Resources	Subbasin Population
1	0	10,650
2	0	8,782
3	0	964
4	0	7,993
5	0	8,229
6	0	1,336
7	1	2,114
8	0	4,416
9	1	3,184
10	0	1,749
11	0	2,186
12	0	21,335
13	0	3,874
14	0	1,356
15	0	29,266
16	0	9,602
17	1	2,307
18	1	2,697

Calculating Summary Scores

Following data aggregation and organization, selected indicators were added to the RPS tool. Associated datasets for each indicator were also inputted. Several screening scenarios were conducted that included various combinations of indicators. Weighting of several indicators was also adjusted in these scenarios. This ability allowed the influences of similar factors to be rapidly assessed and illustrated the relative restorative potential of the selected area. Indicators used and weights applied in each scenario are included in Appendix E along with RPS tool outputs.

For each scenario, RPS tool automatically performs a series of calculations that produce the restoration potential index. This is based on individual summary indices for each of the ecological, stressor and social indicators. A higher RPI score suggests better recovery potential for that subbasin based upon the metrics utilized. Table 6 includes individual indicator scores, subbasin ranks based on the indicator type score, the overall RPI score, and the overall subbasin recovery ranking based on the RPI score for the initial RPS scenario. Additional results are included in Appendix E.

Table 6. Scenario 1 RPS tool indicator scores and rankings

Subbasin ID	Ecological Index	Ecological Rank	Stressor Index	Stressor Rank	Social Index	Social Rank	RPI Score	RPI Rank
1	43.27	7	44.50	13	17.10	7	38.62	10
2	62.71	3	26.68	7	13.80	9	49.95	7
3	56.97	4	6.14	2	0.00	18	50.28	6
4	36.19	12	33.16	8	12.40	11	38.48	11
5	54.37	5	44.22	12	12.85	10	41.00	8
6	79.43	1	2.86	1	0.65	17	59.07	2
7	65.69	2	9.86	3	52.05	4	69.29	1
8	35.54	13	37.68	10	6.10	12	34.65	16
9	39.06	9	39.42	11	53.90	1	51.18	4
10	31.07	15	62.14	17	1.40	15	23.44	18
11	36.39	11	33.26	9	2.15	14	35.09	15
12	22.03	18	50.52	15	36.00	6	35.84	14
13	38.13	10	23.44	5	5.15	13	39.95	9
14	32.07	14	21.12	4	0.70	16	37.22	12
15	28.11	16	69.52	18	50.00	5	36.20	13
16	22.19	17	59.52	16	15.25	8	25.97	17
17	39.19	8	25.06	6	52.35	3	55.49	3
18	45.41	6	44.96	14	53.05	2	51.17	5

Note: color coding matches highlight colors in RPS tool bubble plot outputs

Comparing Results

Rank-ordering, bubble plotting and mapping methods were utilized to illustrate restoration potential of each subbasin. Table 6 includes recovery rankings for each indicator and for the overall RPI scores calculated for the initial scenario. Figure 4 illustrates the ranking of each subbasin using a 3-dimensional bubble plot. Mapped illustrations of the recovery potential for each individual indicator is provided in Figures 5A-C while Figure 5D depicts the RPI calculated for each subbasin within the Matagorda Bay watershed area. Each method presents the same suite of results.

In this initial scenario, subbasin 7 had the highest recovery potential of the watershed while subbasin 10 had the lowest recover potential according to the RPS tool. Subbasins with the highest calculated recovery potential were not surprising, as they are comprised mostly of rural lands with small populations and limited recreational use if any. They also do not contain any current documented bacteria impairment. The subbasins with the lowest calculated recovery potential were situated primarily along the gulf coast and encompassed relatively larger urban areas (Figure 4D).

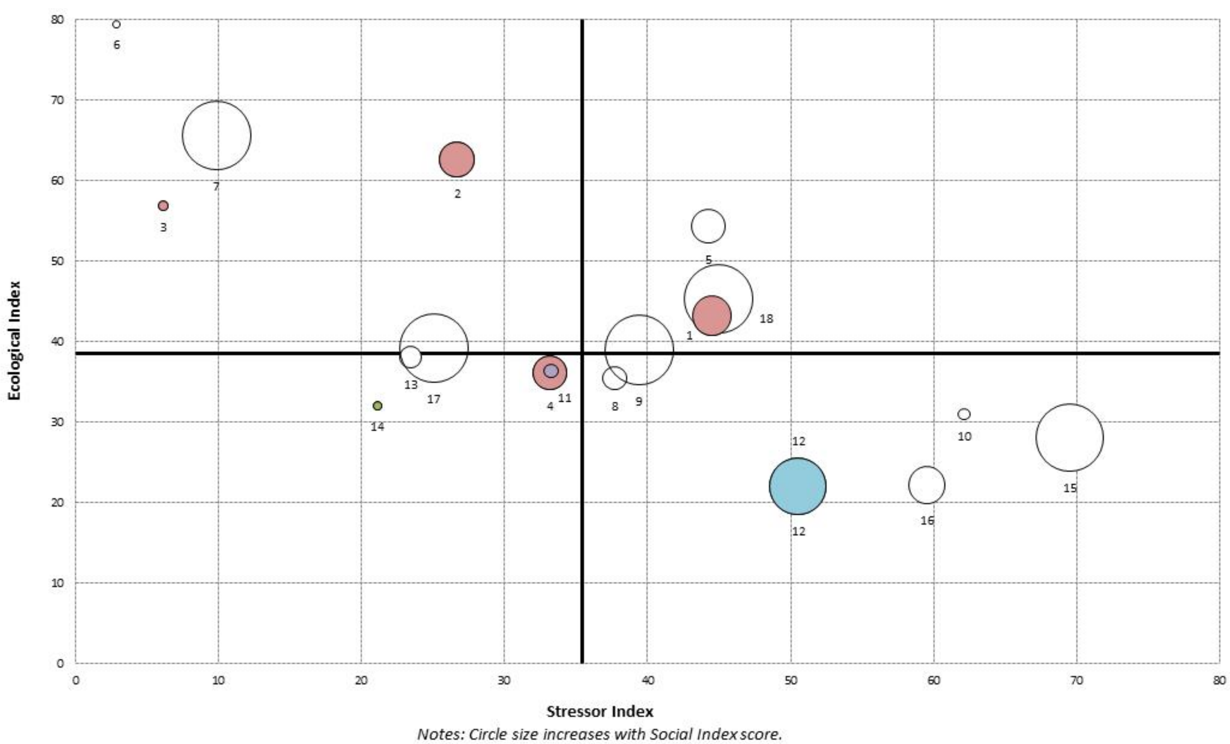

Figure 4. Scenario 1 bubble plot with watershed subbasins containing impaired water bodies highlighted

Subbasins containing current bacteria impaired stream segments were also compared following the initial scenario. The Lavaca River Above Tidal was found to have the highest restoration potential (subbasins 1, 2, 3, 4) and was followed by Arenosa Creek (subbasin 14), Tres Palacios Tidal (subbasin 12) and Carancahua Bay (subbasin 11). Highlighted circles in Figure 4 illustrate the ranking of these impaired water bodies and Appendix E contains additional data and RPS tool output illustrating the comparison between impaired segments of the watershed.

Refined Assessment

As the project progressed, additional data became available that was incorporated into the assessment. Further discussion amongst the project team produced reasonable methods to approximate other indicators suggested in the Candidate Recovery Potential Indicators List. Several other indicators were deemed inappropriate for use in the Matagorda Bay watershed assessment and removed from subsequent assessment scenarios. Discussions also yielded differing thoughts and ideas regarding the influence of listed indicators on water quality. An ad hoc sensitivity analysis was conducted by adjusting weights of individual indicators to allow the project team to further its understanding of the RPS tool. This impromptu assessment enabled more appropriate decisions to be made regarding indicator weight and ultimately led to the final scenario.

Eventually, 4 separate scenarios were determined to reasonably demonstrate the progression of RPS tool application in the project area and illustrate the relative impacts of indicator inclusion and weight. Scenario 1 is presented earlier in this section while all four scenarios are included in Appendix E. Input data tables, RPS tool output tables, bubble plots and maps are provided for each scenario. The 4^{th} and final scenario is considered to represent the restoration potential of the Matagorda Bay watershed's subbasins well.

Using outputs for each indicator and the aggregated RPI for each subbasin as a starting point, the restoration potential of each impaired water body was assessed. RPI scores and rankings for the subbasins making up the Lavaca River Above Tidal were combined yielding an average score (Table 7; rose-colored shading). This average score was compared directly to the scores and rankings of the other impaired segments.

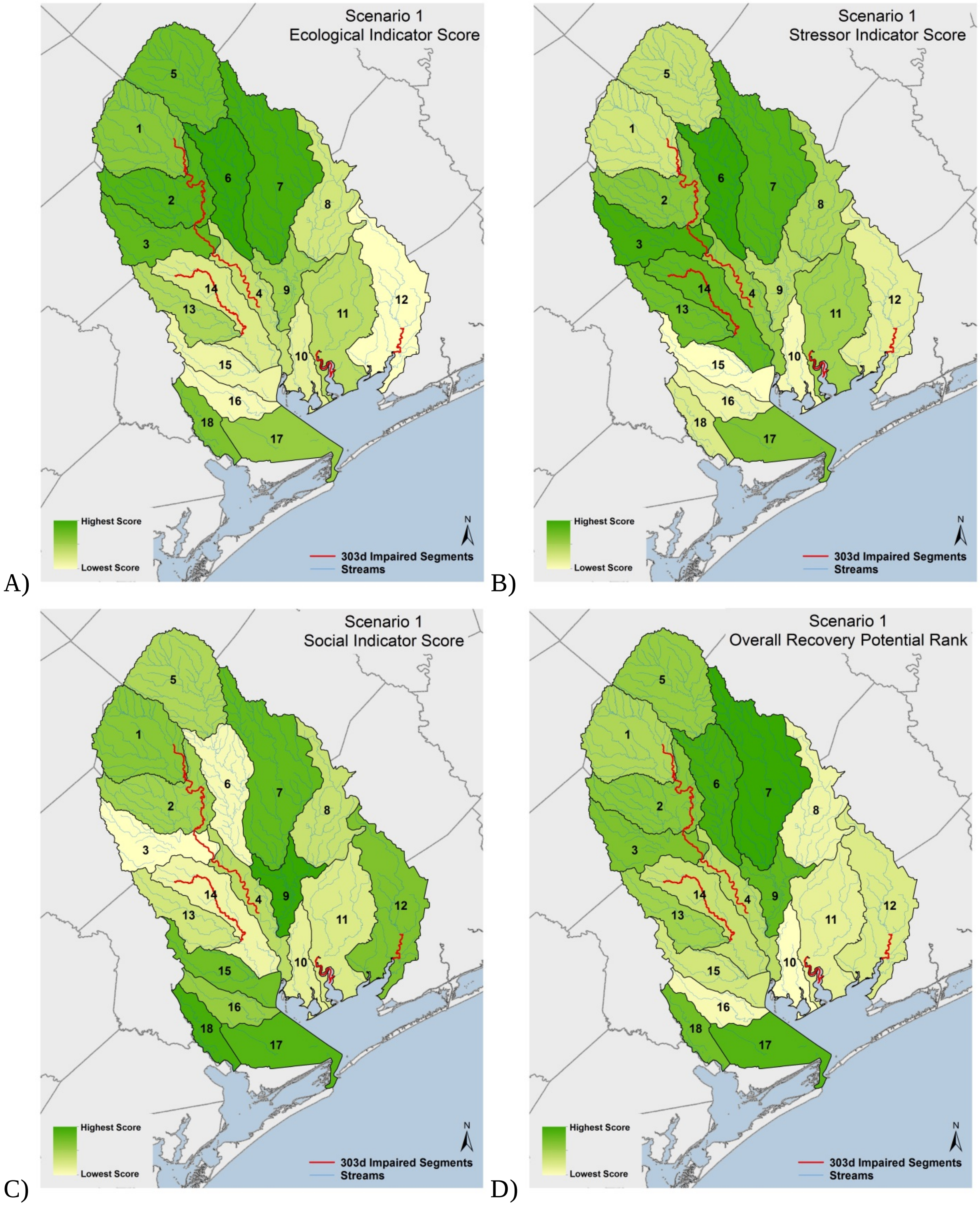

Figure 5. Scenario 1 ecological (A), stressor (B), social (C) and recovery potential index (D) rankings (these figures present ranking data presented in Table 6)

Table 7. RPI ranks and scores for all Scenarios

Subbasin ID	RPI Score	RPI Rank	RPI Score	RPI Rank	RPI Score	RPI Rank	RPI Score	RPI Rank
	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
1	38.62	10	42.98	10	40.22	13	40.10	13
2	49.95	7	53.50	3	52.29	5	52.03	7
3	50.28	6	51.90	5	52.26	6	52.29	6
4	38.48	11	57.05	2	56.03	2	57.05	2
5	41.00	8	44.31	9	43.26	11	43.13	11
6	59.07	2	60.26	1	60.71	1	59.93	1
7	69.29	1	52.17	4	52.62	4	53.33	4
8	34.65	16	51.31	6	52.82	3	55.02	3
9	51.18	4	47.34	7	50.30	7	52.32	5
10	23.44	18	28.42	18	32.74	18	33.79	18
11	35.09	15	36.52	15	37.06	15	37.82	15
12	35.84	14	40.52	12	36.93	16	37.78	16
13	39.95	9	41.60	11	41.68	12	42.55	12
14	37.22	12	45.33	8	46.30	8	48.26	8
15	36.20	13	37.23	14	44.50	10	46.80	9
16	25.97	17	28.50	17	34.26	17	37.01	17
17	55.49	3	40.50	13	44.88	9	45.24	10
18	51.17	5	33.34	16	39.73	14	39.62	14
Lavaca Average	44.33	9	51.35	5	50.20	7	50.37	7

Conclusions

Utility in the Matagorda Bay Watershed

Application of the RPS tool to the Matagorda Bay watershed was completed to assess the restoration potential of the bacteria impaired water bodies it contains. Only 4 water bodies within this area, the Lavaca River Above Tidal, Arenosa Creek, Tres Palacios Creek and Carancahua Bay (color-coded in tables), are impaired. Subbasins draining into these water bodies comprised a relatively small portion of the watershed, thus acquiring data at these small scales presented a minor challenge. As a result, restoration potential of the entire watershed was assessed using coarser scale data. Additionally, this approach provides some context to restoration potential estimates by comparing the impaired watersheds to unimpaired areas.

Once applied and refined, the RPS tool proved effective and provided a consistent and systematic approach to evaluating restoration potential of each subbasin as compared to the others within the watershed. The ability to select metrics appropriate and available for the area of interest greatly increases the utility of this tool, as it can be adapted to any watershed. This enables reasonable assessments of restoration potential to be developed without excessive expenditure of time or resources.

Considering only the impaired water bodies, the tool consistently indicated that the Lavaca River Above Tidal had the highest restoration potential of all of the impaired water bodies. This consistently higher score suggests that it has the best potential for restoration of the impaired water bodies. However, the RPS tool is merely a screening tool, which includes factors that may not appropriately reflect conditions in the subbasin(s) leading to water quality impairments. If the latter is true, the RPS tool may not appropriately represent the real restoration potential of the impaired water bodies.

RPS Tool Utility

Using the RPS tool at refined scales can be problematic when only previously existing data are utilized. Data availability decreases along with size of the focus area thus presenting considerable problems for utilizing this tool. Data limitations did not hinder the assessment of the Matagorda Bay watershed, but were observed in several instances. As a result, this tool is better suited to large-scale assessments such as those occurring at river basin or larger scales. It seems especially suited for a statewide assessment.

A potential pitfall of the RPS tool in assessing the restoration potential of bacteria impaired water bodies is the minimal connection to bacteria sources represented within the potential indicators. Several directly connected indicators are included such as the number of wastewater treatment permits, confined animal feeding operations and septic system; however, many potential sources of bacteria are not accounted for such as wildlife, pets, infrastructure failures, grazing livestock, feral animals and others. The majority of indicators are directly related to instream aquatic habitat restoration, physical water characteristics, or conservative pollutant sources. Loose connections between bacteria loading and many of the included metrics do exist, but these often vary significantly between watersheds. In that sense, a smaller scale assessment is preferred as differences should be minimal within a similar focus area. Bacteria source contributions, its growth, persistence and transport are extremely variable regardless of location thus making the inclusion of effective metrics that appropriately represent the restoration potential of bacteria impaired waters difficult.

Overall, the RPS tool does provide a useful way to at least screen a large number of water bodies or subbasins to assess their relative restoration potential. Its strength is that it depends on readily available data thus enabling relatively quick assessments of large areas thus making it ideal for initial screenings. As long as the RPS tool is used in this regard, it can be an effective aid in prioritizing needed restoration efforts. Attempting to use this tool for more refined assessments is not advised.

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Appendix A: Complete Candidate Recovery Potential Indicators List

ECOLOGICAL METRICS	STRESSOR METRICS	SOCIAL METRICS
Watershed natural structure	**Watershed-level disturbance**	**Leadership, organization and engagement**
watershed % natural cover	watershed % agriculture	watershed organizational leadership
watershed % forest	watershed % cropland	watershed collaboration
watershed wetlands condition	watershed % pasture or grazing	corridor owner-occupied residential
watershed woody veg condition	watershed % steep slope agriculture	government agency involvement
watershed topographic complexity	watershed # of CAFOs	landowner engagement
watershed forest patch mean area	watershed # of septic systems	participation rate in land conservation programs
watershed soil resilience	watershed % impervious cover	large watershed management potential
watershed % streamlength unimpaired	watershed % tile-drained cropland	organizational persistence
watershed shape	watershed % U index (non-natural cover)	university proximity
watershed size	watershed % urban	political support
Corridor and shorelands stability	watershed residential	**Protective ownership or regulation**
bank stability/soils	watershed road density	watershed development risk
bank stability/woody vegetation	other % watershed stressor	watershed % protected land
corridor % forest	**Corridor and shorelands disturbance**	applicable regulation
corridor % woody veg	corridor % impervious cover	**Level of information, certainty and planning**
corridor % wetlands	corridor % tile-drained cropland	community information flow
corridor slope	corridor % U-index (non-natural cover)	certainty of causal linkages
corridor soil erosion potential	corridor % urban	% identified stressor sources
corridor soil type	corridor % agriculture	certainty of restoration practices
shoreline % forested	corridor % cropland	TMDL or other plan existence
shoreline % woody veg	corridor % pasture or grazing	watershed education level
Flow and channel dynamics	linear % of channel through agriculture	ratio #TMDLs/#impairments
natural channel form	corridor residential	% of stream miles assessed
corridor groundwater level	corridor road crossings	% of lake acres assessed
channel slope	corridor road density	**Restoration cost, difficulty, or complexity**
sinuosity	shoreline % linear U index (non-natural cover)	estimated restoration cost
confinement ratio	% flowpaths through agriculture	watershed size
channel evolution status	**Hydrologic alteration**	# of upstream HUC12s
natural flow regime	aquatic barriers	impaired waterbody magnitude
median and low-flow maintenance	channelization	jurisdictional complexity
Strahler stream order	distance downstream from channelization	landownership complexity
% flowpaths through natural cover	distance downstream from dam	recovery time frame
Biotic community integrity	distance to nearest dam	**Socio-economic considerations**
watershed biodiversity	hydrologic alteration	watershed population below fed poverty level
aquatic refugia	watershed % other channelization	Environmental Justice area of concern
biotic community type	relative net water demand	sewer expenditures
biotic community integrity	water use intensity	watershed total annual personal income
Index of biotic integrity (benthic)	% bermed roads	debt/revenue ratio
Index of biotic integrity (fish)	**Biotic or climatic risks**	utility revenue
mussel species richness	elevation	water utility expenditures
rare taxa presence	invasive species presence	tax revenue
trophic state	invasive species risk	total local indebtedness
NFHAP fish habitat condition index	**Severity of pollutant loading**	local govt general revenue
Aquatic connectivity	number of 303d listed causes	local socio-economic conditions
confluence density	number of 303d cause/waterbody combinations	own local revenue
unimpaired confluences density	number of permits	park expenditures
watershed stream density	CSO or MS4 areas	real estate value
contiguity with green infrastructure corridor	age of sewer infrastructure	sustainability
proximity to green infrastructure hub	severity of loading	**Human health, beneficial uses, recognition and incentives**
recolonization access	stressor persistence	watershed population
recolonization proximity	SPARROW nitrogen loading estimate	recreational resource
Ecological history	SPARROW phosphorus loading estimate	watershed # of drinking water intakes
maintenance of % natural cover	watershed stream miles impaired	watershed % sourcewater protection area
ratio current/historic % forest	watershed waterbody acres impaired	drinking water population served
ratio current/historic % wetlands	modeled watershed aerial deposition of N	designated uses
historical species occurrence	modeled watershed aerial deposition of Hg	valued ecological attribute
species range	other stressor-specific severity factors	economic incentive
ecological memory	**Legacy of past, trajectory of future land use**	funding eligibility
	expected future loadings	human health and safety
	past land use change trajectory	community identity (iconic value)
	legacy land uses	303d schedule priority
	watershed % legacy agriculture	other priority recognition
	watershed % legacy urban	wild, scenic, recreational river designation
	watershed % change in U-index (non-natural cover)	area of critical environmental concern
	corridor % legacy agriculture	other use values
	corridor % legacy urban	
	corridor % residential growth	
	legacy contaminants	
	legacy sediments	

Appendix B: Candidate Recovery Potential Indicators

USEPA Office of Water Recovery Potential Screening Website 09/01/2011
http://www.epa.gov/recoverypotential/

Selection and Weighting Worksheet for Recovery Potential Indicators

Selection Instructions: You can treat this form not as rigid guidance but as a menu of candidate indicator concepts to stimulate workgroup thinking, discussion and indicator selection. 1) Select the indicators that are appropriate to the study area and the primary purpose of your recovery potential screening; see indicator summaries and indicator-specific fact sheets at http://www.epa.gov/recoverypotential/ for more information about individual metrics. 2) Modify or write in additional indicators in the appropriate columns, as desired. 3) Weighting your indicators: To reflect your initial assumptions of each indicator's importance to recovery potential in your area, assign a weighting factor from 1 to 5 to each of the indicators (5 is highest) or leave all of them at equal weighting. 4) Merge the completed sheets from your workgroup to identify candidate indicators and weights, then use group results to work on consensus for indicator selection.

Name: TWRI **Date:** Candidate

Project: Applying RPS to Matagorda Bay Watersheds **Location:** Matagorda Bay Watersheds/River Basins 15,16,17

	ECOLOGICAL METRICS		STRESSOR METRICS		SOCIAL CONTEXT METRICS
Watershed natural structure		**Watershed-level disturbance**		**Leadership, organization and engagement**	
✓	watershed % natural cover	✓	watershed % agriculture		watershed organizational leadership
✓	watershed % forest		watershed % steep slope agriculture		watershed collaboration
✓	watershed % wetlands		watershed # of CAFOs		corridor owner-occupied residential
✓	watershed woody vegetation	✓	watershed # of septic systems		government agency involvement
	watershed topographic complexity	✓	watershed % impervious cover		participation rate in land conservation programs
	watershed forest patch mean area		watershed % tile-drained cropland		large watershed management potential
	watershed soil resilience		watershed % U index (non-natural cover)		university proximity
✓	watershed % streamlength unimpaired	✓	watershed % urban		political support
	watershed shape	✓	watershed road density	**Protective ownership or regulation**	
✓	watershed size	**Corridor or near-shore disturbance**		✓	watershed % protected land
Corridor and shorelands stability			corridor % impervious cover		applicable regulation
	bank stability/soils		corridor % tile-drained cropland	**Level of information, certainty and planning**	
	bank stability/woody vegetation		corridor % U-index		certainty of causal linkages
	corridor % forest		corridor % urban		% identified stressor sources
	corridor % woody veg		corridor % agriculture		certainty of restoration practices
	corridor % wetlands		linear % of channel through agriculture	✓	TMDL or other plan existence
	corridor slope		corridor road crossings		watershed education level
	corridor soil erosion potential		corridor road density	✓	ratio #TMDLs/#impairments
	corridor soil type	**Hydrologic alteration**			% of stream miles assessed
	shoreline % forested		aquatic barriers		% of lake acres assessed
	shoreline % woody veg		channelization	**Restoration cost, difficulty, or complexity**	
Flow and channel dynamics			hydrologic alteration		estimated restoration cost
	natural channel form		relative net water demand		jurisdictional complexity
	corridor groundwater level		water use intensity		landownership complexity
	channel slope	**Biotic or climatic risks**			recovery time frame
	sinuosity		elevation	**Socio-economic considerations**	
	confinement ratio		invasive species risk		Environmental Justice area of concern
	channel evolution status	**Severity of pollutant loading**			local socio-economic conditions
	fine sediment transport capacity	✓	number of 303(d) listed causes	**Human health, beneficial uses, recognition and incentives**	
	natural flow regime	✓	number of permits	✓	watershed population

✓	ECOLOGICAL METRICS	✓	STRESSOR METRICS	✓	SOCIAL CONTEXT METRICS
	median-flow maintenance	✓	CSO or MS4 areas	✓	recreational resource
	low-flow maintenance	✓	age of sewer infrastructure		# of drinking water intakes
	Strahler stream order		severity of loading		watershed % source water protection area
	Biotic community integrity		stressor persistence		valued ecological attribute
	biotic community integrity		SPARROW nitrogen loading estimate		funding eligibility
	rare taxa presence		SPARROW phosphorus loading estimate		human health and safety
	trophic state	✓	watershed stream miles impaired		community identity (iconic value)
	NFHAP fish habitat condition index		watershed waterbody acres impaired		303(d) schedule priority
	Aquatic connectivity		modeled watershed aerial deposition of N		
	confluence density		modeled watershed aerial deposition of Hg		
	unimpaired confluences density		other stressor-specific severity factors		
✓	watershed stream density		**Legacy of past, trajectory of future land use**		
	contiguity with green infrastructure corridor		land use change trajectory		
	proximity to green infrastructure hub		legacy land uses		
	recolonization access		watershed % legacy agriculture		
	Ecological history		watershed % legacy urban		
	maintenance of % natural cover		corridor % legacy agriculture		
✓	ratio current/historic % forest		corridor % legacy urban		
✓	ratio current/historic % wetlands				
	historical species occurrence				
	species range				
	Other ecological factors (write in)		**Other stressor-related factors (write in)**		**Other social context traits (write in)**
		✓	Watershed % cropland	✓	Watershed size
		✓	Watershed % pasture/grazing	✓	# of upstream HUC12s

Appendix C: Data Source List

Data Source	Website	Description
911 Address Points	N/A: Obtained directly from area Councils of Government	Building addresses used to aid in approximating OSSF number and location
2013 National Agricultural Imagery Program	N/A: Standard ArcGIS Basemap Imagery layer available in ArcMap 10.x	1m resolution Satellite imagery for use in approximating OSSF number and location; general watershed observations
2006 National Land Cover Database (NLCD)	http://www.mrlc.gov/finddata.php	Land use and land cover data
Strategic Mapping Program (StratMap)	https://www.tnris.org/StratMap	Transportation data for road crossings; city limit boundaries
Texas Commission on Environmental Quality (TCEQ)	http://www.tceq.state.tx.us/waterquality/tmdl/hydromaps.html http://www1.tceq.texas.gov/wqpaq/	TCEQ designated assessment units; stream length measurements; permit data and numbers
2010 United States Census	http://www.census.gov/geo/maps-data/	Population and number of housing units data provided at the Census block level; city limit boundaries
United States Department of Agriculture – Natural Resource Conservation Service (USDA-NRCS)	http://datagateway.nrcs.usda.gov/	HUC 10 & 12 watershed delineation, shape, and size
National Hydrography Data set	http://nhd.usgs.gov/	National water resource map used for determining stream locations and length

Appendix D: RPS Tool Indicator Definitions and Measurements

Ecological Indicators

% Natural Cover:
the percent of total land area in the subbasin that is covered by forest, shrubland, wetlands, grassland, and barren land as mapped in the National Land Cover Database (NLCD) 2006 land use and land cover data layer.

% Forest:
the percent of the subbasin area that is covered by forests (deciduous, evergreen or mixed) as mapped in the NLCD 2006 land use and land cover data layer.

% Wetlands:
the percent of total subbasin land area covered by wetlands (woody and emergent) as mapped in the NLCD 2006 land use and land cover data layer.

% Woody Veg:
the percent of the subbasin area covered by woody plants (deciduous, evergreen or mixed forests and shrubland) as mapped in the NLCD 2006 land use and land cover data layer.

% Stream length Unimpaired:
the portion of stream length within the subbasin that is not currently impaired and is measured as the miles of impaired streams divided by the miles of total stream length in each subbasin. Impaired stream length data was selected from TCEQ assessment unit maps and total stream length was estimated using the National Hydrography Dataset water bodies labeled as perennial, intermittent or artificial paths known to be a part of the stream network.

Acres (Subbasin Size):
a direct measurement of the area of each subbasin in acres as delineated in the U.S. Department of Agriculture – Natural Resource Conservation Service's Watershed Boundary Data layer.

Corridor % Forest:
the percent of the stream corridor within the subbasin that is encompassed by forested land (deciduous, evergreen or mixed) as mapped in the NLCD 2006 land use and land cover data layer. The corridor was defined as 25 meters either side of TCEQ assessment

units and 10 meters either side all other perennial, intermittent or artificial paths in the subbasin.

Corridor % Woody Veg:
the percent of the stream corridor that is covered with shrubland or forested land covers as mapped in the NLCD 2006 land use and land cover data layer. The corridor was defined as 25 meters either side of TCEQ assessment units and 10 meters either side all other perennial, intermittent or artificial paths in the subbasin.

Corridor % Wetland:
the percent of the stream corridor that is covered with wetlands (emergent or woody) as mapped in the NLCD 2006 land use and land cover data layer. The corridor was defined as 25 meters either side of TCEQ assessment units and 10 meters either side all other perennial, intermittent or artificial paths in the subbasin.

Stressor Indicators

% Agriculture:
calculated as the percent of subbasin area that is comprised of cropland or pasture land as mapped in the NLCD 2006 land use and land cover data layer.

% Impervious Cover:
the percent of subbasin area that is classified as developed (low, medium or high density) as mapped in the NLCD 2006 land use and land cover data layer.

% Urban:
the percentage of subbasin area within that is classified as developed (low, medium or high density; developed open space) as mapped in the NLCD 2006 land use and land cover data layer.

# of Permits:
a count of the total number of domestic wastewater treatment facility and stormwater discharge permits in each subbasin according to TCEQ permits database.

Watershed # of Septic Systems:
the number of estimated septic systems in each subbasin. These numbers were developed from 2010 Census housing units per Census block, 911 address points, and recent aerial imagery to approximate septic system density and distribution.

Corridor % Impervious Cover:
the percent of impervious cover in each subbasin and is measured by the amount of low, medium or high density developed land in each subbasin as mapped in the NLCD 2006

land use and land cover data layer. The corridor was defined as 25 meters either side of TCEQ assessment units and 10 meters either side all other perennial, intermittent or artificial paths in the subbasin.

Corridor % Urban:
the percent of the stream corridor in each subbasin that is classified as low, medium or high density developed in the NLCD 2006 land use and land cover data layer. The corridor was defined as 25 meters either side of TCEQ assessment units and 10 meters either side all other perennial, intermittent or artificial paths in the subbasin.

Corridor % Agriculture:
the percent of the stream corridor in each subbasin that is classified as cropland or pasture land in the NLCD 2006 land use and land cover data layer. The corridor was defined as 25 meters either side of TCEQ assessment units and 10 meters either side all other perennial, intermittent or artificial paths in the subbasin.

Corridor Road Crossings:
the number of road crossings within the stream corridor in each subbasin as counted using the Strategic Mapping Program's (StratMap) transportation layer and corridor sizes of 25 meters either side of TCEQ assessment units and 10 meters either side all other perennial, intermittent or artificial paths in the subbasin.

Social Indicators

Population:
the number of persons estimated to reside in each subbasin according to 2010 Census block population information.

% Stream Miles Assessed:
the percent of total stream miles assessed by TCEQ biannually within each subbasin. This is calculated by dividing the total length of assess miles in TCEQ assessment unit maps by the total stream length estimated using the National Hydrography Dataset water bodies labeled as perennial, intermittent or artificial paths known to be a part of the stream network.

Indicators Initially Selected but Removed

Stream Density:
the total length of stream miles divided by subbasin area and provides an idea of the overall quantity of streams in each subbasin per unit area.

Road Density:
the total length of road miles divided by subbasin area and provides an idea of the overall quantity of roads in each subbasin per unit area.

Recreational Resource:
a notation of whether or not water bodies flow through recreational use land (public land).

Appendix E: RPS Tool Outputs – All Scenarios

Scenario 1

Table E-1. Indicators included in RPS Tool Scenario 1 assessment

Ecological Indicators	Stressor Indicators	Social Indicators
Stream Density	% Agricultural Land Use	# of Recreational Resources
% of Natural Cover	% Impervious Cover	Population
% Forests	% Urban	
% Wetlands	Road Density	
% Woody Vegetation	# of WWTF Outfall Permits	
% Unimpaired Stream Length		
Subbasin Size (Acres)		

Table E-2. Raw data for ecological indicators used in Scenario 1

Subbasin ID	*Stream Density	% Natural Cover	% Forest Area	% Wetland Area	% Woody Vegetation	% of Streams Unimpaired	Subbasin Size Total (Acres)
1	0.0005	28.17	8.08	3.85	25.67	99.84	198,400
2	0.0005	53.27	28.68	7.89	49.50	99.88	166,300
3	0.0003	60.56	31.32	7.65	56.36	99.90	123,151
4	0.0003	42.47	14.79	12.85	34.22	99.73	94,510
5	0.0005	31.18	11.93	7.42	29.30	100.00	212,173
6	0.0005	71.85	42.51	8.66	67.80	100.00	150,328
7	0.0004	45.01	24.82	5.82	42.30	100.00	295,797
8	0.0004	12.51	3.81	4.97	11.31	100.00	156,194
9	0.0004	25.94	10.15	7.23	21.37	100.00	82,541
10	0.0002	34.62	1.54	8.77	22.02	100.00	69,546
11	0.0002	22.31	7.15	4.89	16.20	100.00	220,252
12	0.0003	13.85	2.38	5.13	9.79	99.64	235,056
13	0.0003	36.34	12.79	3.59	30.75	99.92	104,283
14	0.0003	25.20	4.69	7.21	17.46	99.86	158,576
15	0.0003	15.27	1.80	3.06	11.44	100.00	104,771
16	0.0003	8.11	0.90	1.73	5.38	100.00	73,378
17	0.0001	46.26	0.98	25.04	19.83	100.00	132,030
18	0.0002	51.85	1.72	40.06	19.29	100.00	60,957

*stream density calculated by dividing stream miles in subbasin by subbasin size

Table E-3. Raw data for stressor indicators used in Scenario 1

Subbasin ID	% Agriculture Area	% Impervious Cover	% Urban Area	*Road Density	# of Stormwater and Wastewater Outfall Permits
1	65.04	0.25	0.85	0.0011	3
2	41.09	0.20	0.87	0.0008	1
3	34.92	0.03	0.16	0.0005	0
4	50.13	0.58	1.98	0.0007	3
5	62.11	0.22	0.80	0.0011	4
6	23.52	0.01	0.11	0.0005	0
7	51.69	0.01	0.10	0.0004	1
8	82.96	0.06	0.36	0.0009	3
9	68.99	0.16	1.01	0.0009	2
10	57.62	1.47	2.76	0.0004	29
11	74.22	0.01	0.20	0.0007	12
12	79.29	0.40	1.51	0.0009	9
13	58.53	0.21	0.60	0.0007	2
14	70.96	0.08	0.23	0.0006	0
15	75.42	2.36	4.25	0.0008	2
16	71.32	0.91	2.32	0.0010	2
17	48.13	0.50	1.51	0.0004	9
18	39.19	1.10	2.54	0.0005	22

*Road density calculated by dividing length of roadway in subbasin-by-subbasin size

Table E-4. Raw data for social indicators used in Scenario 1

Subbasin ID	Recreational Resources	Subbasin Population
1	0	10,650
2	0	8,782
3	0	964
4	0	7,993
5	0	8,229
6	0	1,336
7	1	2,114
8	0	4,416
9	1	3,184
10	0	1,749
11	0	2,186
12	0	21,335
13	0	3,874
14	0	1,356
15	0	29,266
16	0	9,602
17	1	2,307
18	1	2,697

Table E-5. Scenario 1 RPS tool screening indicator scores and rankings

Subbasin ID	Ecological Index	Ecological Rank	Stressor Index	Stressor Rank	Social Index	Social Rank	RPI Score	RPI Rank
1	43.27	7	44.50	13	17.10	7	38.62	10
2	62.71	3	26.68	7	13.80	9	49.95	7
3	56.97	4	6.14	2	0.00	18	50.28	6
4	36.19	12	33.16	8	12.40	11	38.48	11
5	54.37	5	44.22	12	12.85	10	41.00	8
6	79.43	1	2.86	1	0.65	17	59.07	2
7	65.69	2	9.86	3	52.05	4	69.29	1
8	35.54	13	37.68	10	6.10	12	34.65	16
9	39.06	9	39.42	11	53.90	1	51.18	4
10	31.07	15	62.14	17	1.40	15	23.44	18
11	36.39	11	33.26	9	2.15	14	35.09	15
12	22.03	18	50.52	15	36.00	6	35.84	14
13	38.13	10	23.44	5	5.15	13	39.95	9
14	32.07	14	21.12	4	0.70	16	37.22	12
15	28.11	16	69.52	18	50.00	5	36.20	13
16	22.19	17	59.52	16	15.25	8	25.97	17
17	39.19	8	25.06	6	52.35	3	55.49	3
18	45.41	6	44.96	14	53.05	2	51.17	5

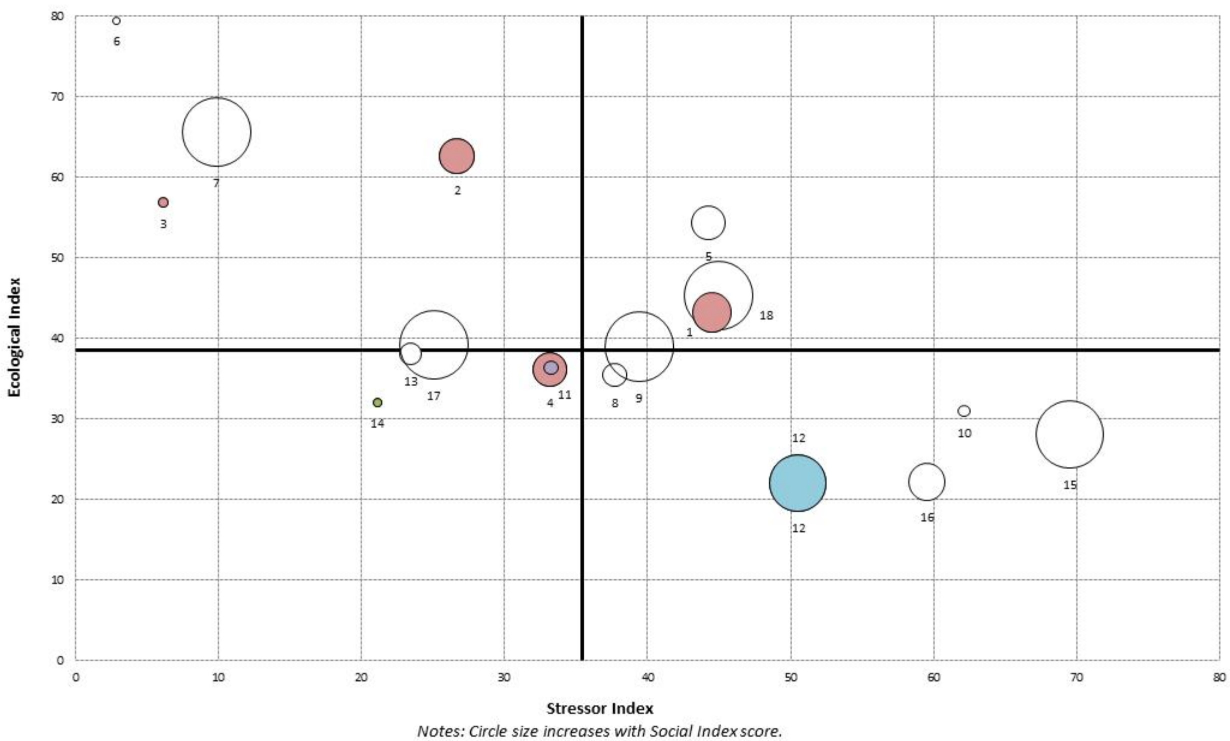
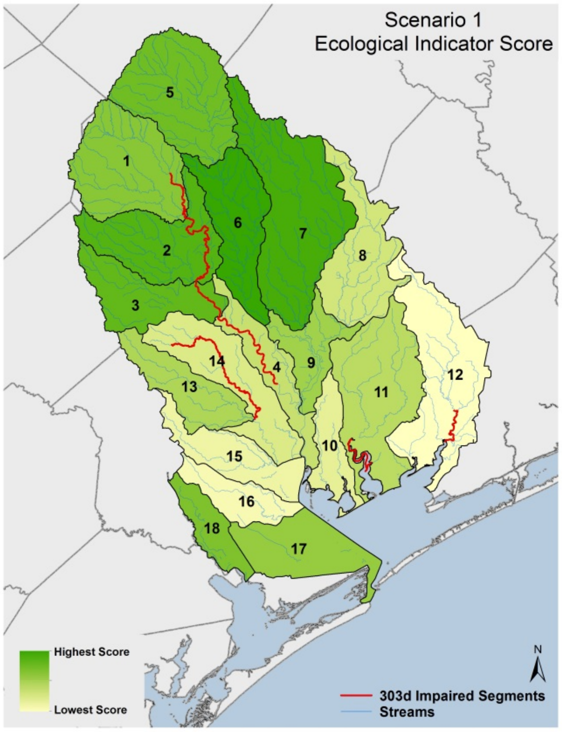
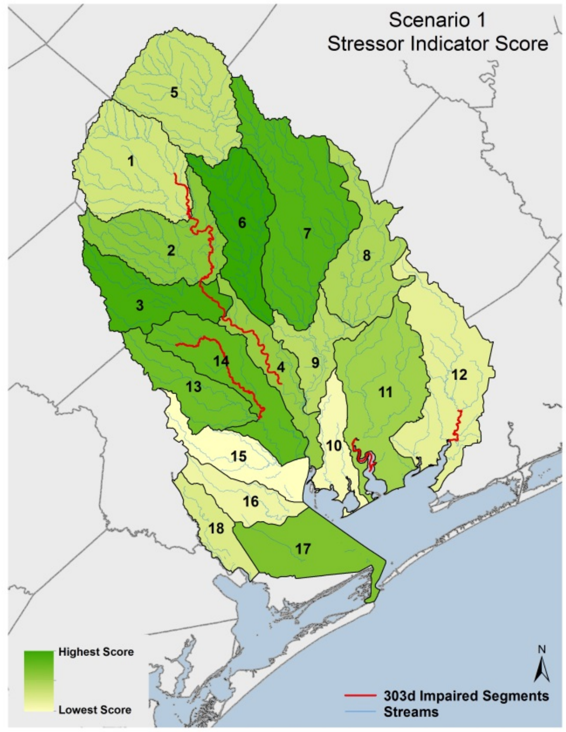


Figure E-1. Scenario 1 bubble plot showing overall RPI ranking of individual subbasins (Shaded bubbles are impaired waters, see Table 1 for description)



A)



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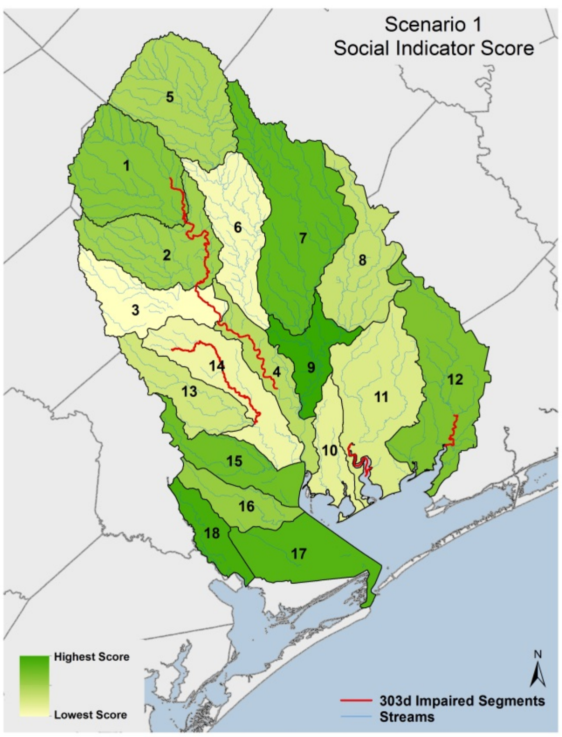
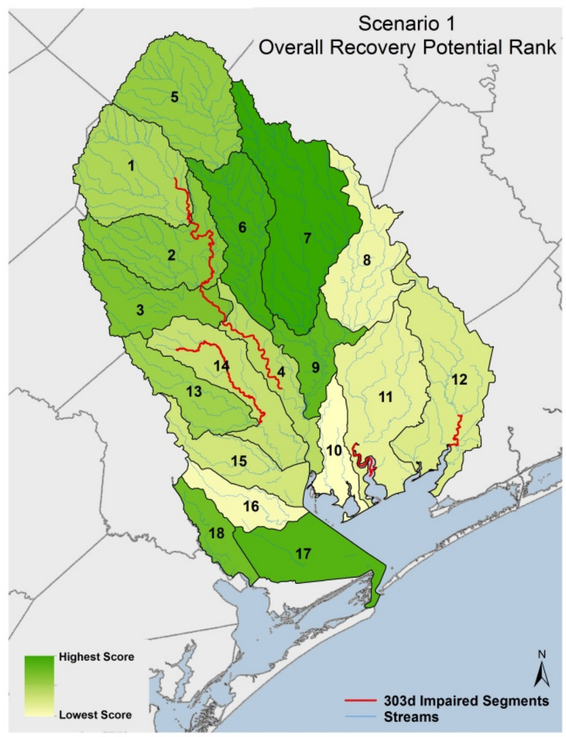


C)



D)

Figure E-2. Scenario 1 ecological (A), stressor (B), social (C) and recovery potential index (D) rankings

Scenario 2

Table E-6. Indicators included in RPS Tool Scenario 2 assessment

Ecological Indicators	Stressor Indicators	Social Indicators
% of Natural Cover	% Agricultural Land Use	% of Stream Miles Assessed
% Forests	% Impervious Cover	Population
% Wetlands	% Urban	
% Woody Vegetation	# of subbasin septic systems	
% Unimpaired Stream Length	# of WWTF/SW Permits	
Subbasin Size (Acres)	Corridor % Impervious Cover	
Corridor % Forest	Corridor % Urban	
Corridor % Woody Vegetation	Corridor % Agriculture	
Corridor % Wetland	Corridor # Road Crossings	

Table E-7. Raw data for ecological indicators used in Scenario 2

Subbasin ID	% Natural Cover	% Forest Area	% Wetland Area	% Woody Veg.	% of Streams Unimpaired	Subbasin Size Total (Acres)	Corridor % Forest	Corridor % Woody Veg.	Corridor % Wetland
1	28.17	8.08	3.85	25.67	99.84	198,400	15.46	20.17	26.89
2	53.27	28.68	7.89	49.50	99.88	166,300	30.75	11.85	37.08
3	60.56	31.32	7.65	56.36	99.90	123,151	30.44	16.28	30.59
4	42.47	14.79	12.85	34.22	99.73	94,510	8.97	6.24	39.77
5	31.18	11.93	7.42	29.30	100.00	212,173	23.02	13.46	36.18
6	71.85	42.51	8.66	67.80	100.00	150,328	32.27	12.73	38.86
7	45.01	24.82	5.82	42.30	100.00	295,797	32.09	12.84	32.60
8	12.51	3.81	4.97	11.31	100.00	156,194	9.67	7.10	41.77
9	25.94	10.15	7.23	21.37	100.00	82,541	13.72	5.90	32.22
10	34.62	1.54	8.77	22.02	100.00	69,546	1.03	18.47	21.6
11	22.31	7.15	4.89	16.20	100.00	220,252	11.72	8.40	20.06
12	13.85	2.38	5.13	9.79	99.64	235,056	4.84	4.72	26.69
13	36.34	12.79	3.59	30.75	99.92	104,283	14.35	19.15	20.13
14	25.20	4.69	7.21	17.46	99.86	158,576	5.61	9.93	35.16
15	15.27	1.80	3.06	11.44	100.00	104,771	4.05	13.14	19.91
16	8.11	0.90	1.73	5.38	100.00	73,378	5.55	7.16	18.98
17	46.26	0.98	25.04	19.83	100.00	132,030	0.42	4.80	42.58
18	51.85	1.72	40.06	19.29	100.00	60,957	1.12	3.43	46.38

Table E-8. Raw data for stressor indicators used in Scenario 2

Subbasin ID	% Ag. Area	% Impervious Cover	% Urban Area	# of Septic Systems	# of WWTF and SW Permits	Corridor % Impervious	Corridor % Urban	Corridor % Ag.	Corridor # Road Crossings
1	65.04	0.25	0.85	2,556	3	0.03	0.25	32.89	1181
2	41.09	0.20	0.87	1,459	1	0.03	0.29	16.70	678
3	34.92	0.03	0.16	495	0	0.00	0.18	18.90	439
4	50.13	0.58	1.98	768	3	0.15	0.67	18.77	234
5	62.11	0.22	0.80	2,464	4	0.02	0.29	22.81	1046
6	23.52	0.01	0.11	894	0	0.00	0.09	9.07	577
7	51.69	0.01	0.10	846	1	0.00	0.21	15.27	483
8	82.96	0.06	0.36	1,043	3	0.02	0.27	37.78	312
9	68.99	0.16	1.01	545	2	0.05	0.18	28.32	91
10	57.62	1.47	2.76	287	29	0.07	0.48	50.61	122
11	74.22	0.01	0.20	1,548	12	0.05	0.13	45.94	346
12	79.29	0.40	1.51	2,079	9	0.16	1.03	49.91	544
13	58.53	0.21	0.60	1,193	2	0.00	0.16	43.40	121
14	70.96	0.08	0.23	484	0	0.04	0.23	35.29	227
15	75.42	2.36	4.25	929	2	0.42	1.11	53.53	168
16	71.32	0.91	2.32	734	2	0.19	0.76	58.92	79
17	48.13	0.50	1.51	595	9	0.21	1.34	32.77	104
18	39.19	1.10	2.54	72	22	0.39	2.51	16.89	116

Table E-9. Raw data for social indicators used in Scenario 2

Subbasin ID	% of Total Stream Miles Assessed	Subbasin Population
1	9.45	10,650
2	7.37	8,782
3	2.39	964
4	38.10	7,993
5	4.41	8,229
6	9.75	1,336
7	2.89	2,114
8	31.29	4,416
9	20.32	3,184
10	0.00	1,749
11	5.30	2,186
12	15.15	21,335
13	1.12	3,874
14	17.24	1,356
15	0.00	29,266
16	0.00	9,602
17	8.61	2,307
18	0.00	2,697

Table E-10. Scenario 2 RPS tool screening indicator scores and rankings

Subbasin ID	Ecological Index	Ecological Rank	Stressor Index	Stressor Rank	Social Index	Social Rank	RPI Score	RPI Rank
1	42.11	7	42.67	13	29.50	6	42.98	10
2	61.18	4	24.13	7	23.45	7	53.50	3
3	62.48	3	9.94	2	3.15	16	51.90	5
4	35.87	10	27.13	8	62.40	1	57.05	2
5	52.70	5	38.42	12	18.65	9	44.31	9
6	76.02	1	8.70	1	13.45	12	60.26	1
7	65.57	2	14.96	3	5.90	15	52.17	4
8	34.21	11	27.44	9	47.15	4	51.31	6
9	33.70	12	22.22	6	30.55	5	47.34	7
10	32.67	14	48.82	16	1.40	18	28.42	18
11	33.20	13	32.73	10	9.10	13	36.52	15
12	17.10	17	51.44	17	55.90	2	40.52	12
13	39.86	9	21.67	5	6.60	14	41.60	11
14	32.08	15	19.43	4	23.35	8	45.33	8
15	24.40	16	62.71	18	50.00	3	37.23	14
16	15.97	18	45.72	14	15.25	10	28.50	17
17	40.96	8	33.10	11	13.65	11	40.50	13
18	43.90	6	46.94	15	3.05	17	33.34	16

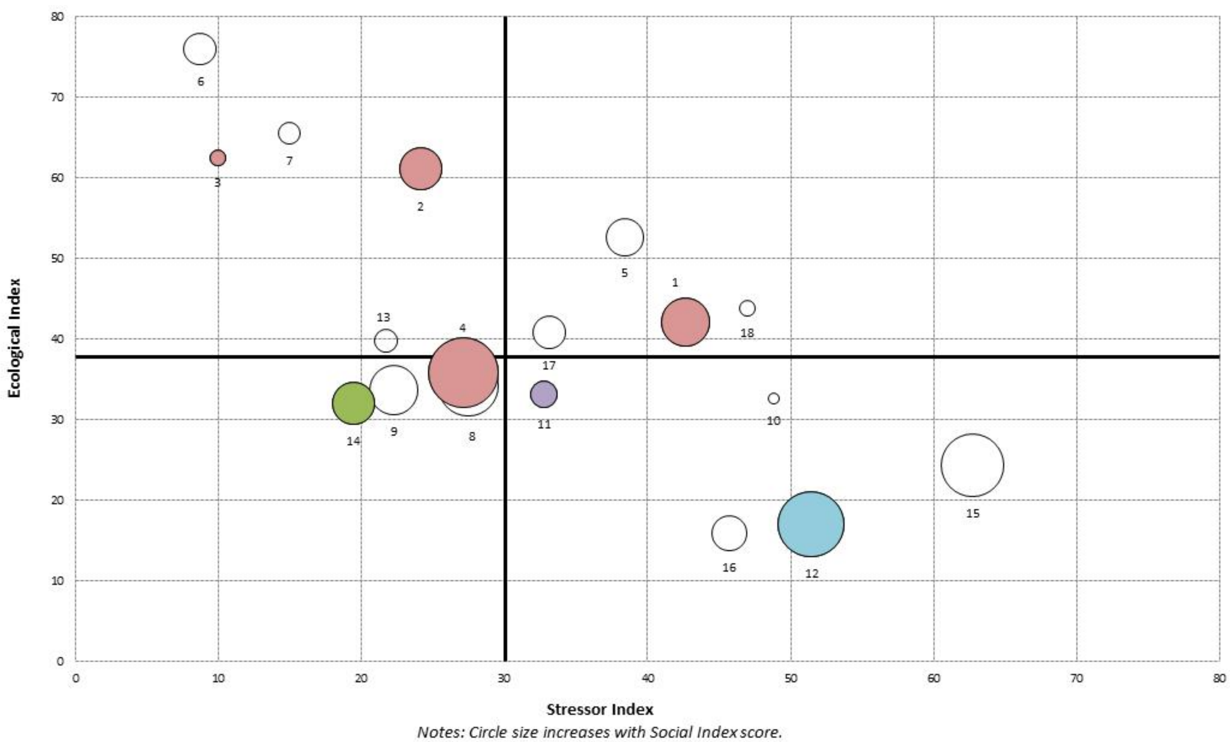


Figure E-3. Scenario 2 bubble plot showing overall RPI ranking of individual subbasins (Shaded bubbles are impaired waters, see Table 1 for description)

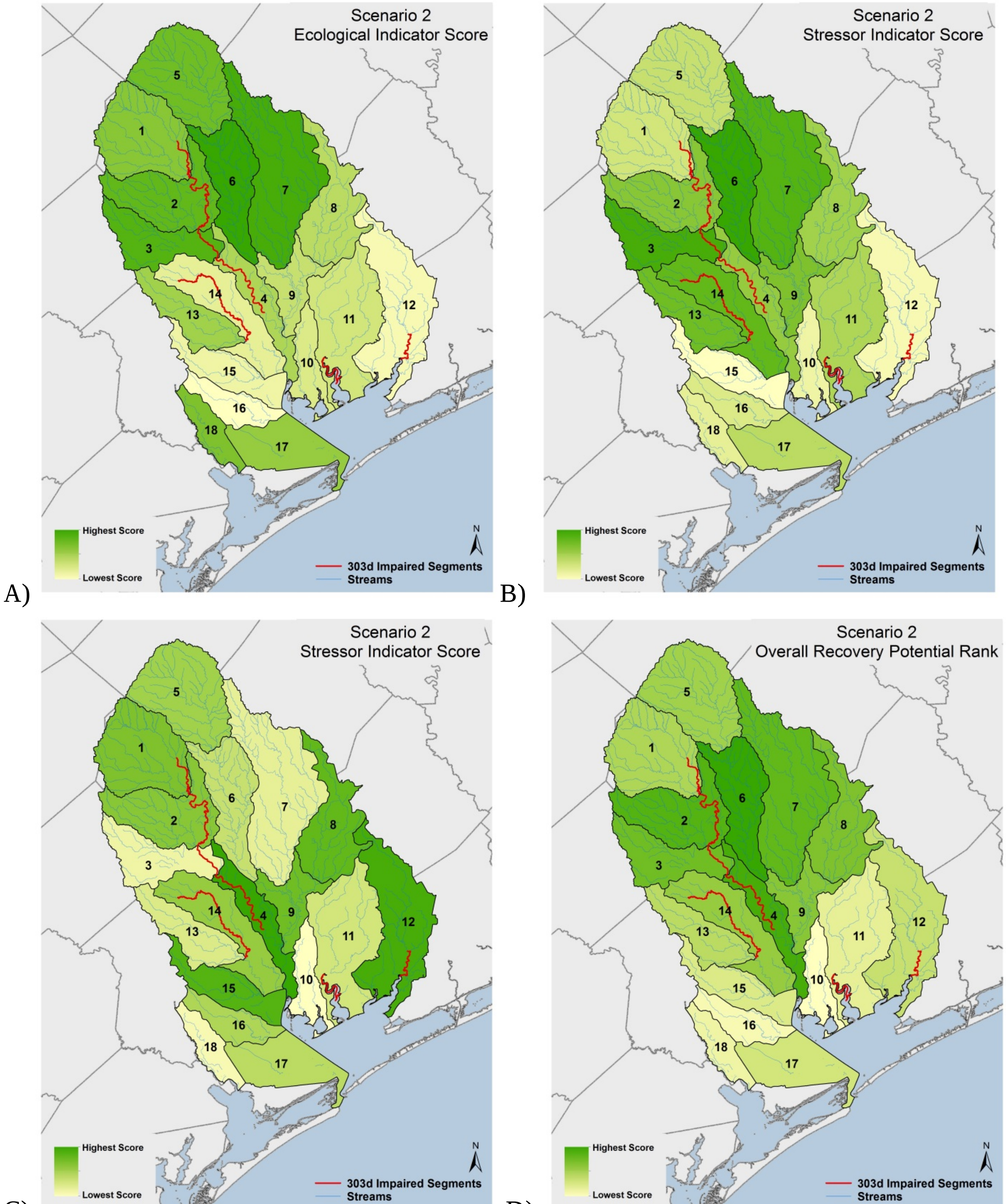


Figure E-4. Scenario 2 ecological (A), stressor (B), social (C) and recovery potential index (D) rankings

Scenario 3

Table E-11. Indicators included in RPS Tool Scenario 3 assessment

Ecological Indicators	Weight Applied	Stressor Indicators	Weight Applied	Social Indicators	Weight Applied
% of Natural Cover	1	% Ag. Land Use	3	% of Stream Miles Assessed	1
% Forests	1	% Impervious Cover	2	Population	1
% Wetlands	1	% Urban	1		
% Woody Veg.	1	# of subbasin OSSFs	5		
% Unimpaired Stream Length	3	# of WWTF/SW Permits	3		
Subbasin Size (Acres)	1	Corridor % Impervious Cover	1		
Corridor % Forest	1	Corridor % Urban	1		
Corridor % Woody Veg.	1	Corridor % Ag.	1		
Corridor % Wetland	1	Corridor # Road Crossings	1		

Table E-12. Raw data for ecological indicators used in Scenario 3

Subbasin ID	% Natural Cover	% Forest Area	% Wetland Area	% Woody Veg.	% of Streams Unimpaired	Subbasin Size Total (Acres)	Corridor % Forest	Corridor % Woody Veg.	Corridor % Wetland
1	28.17	8.08	3.85	25.67	99.84	198,400	15.46	20.17	26.89
2	53.27	28.68	7.89	49.50	99.88	166,300	30.75	11.85	37.08
3	60.56	31.32	7.65	56.36	99.90	123,151	30.44	16.28	30.59
4	42.47	14.79	12.85	34.22	99.73	94,510	8.97	6.24	39.77
5	31.18	11.93	7.42	29.30	100.00	212,173	23.02	13.46	36.18
6	71.85	42.51	8.66	67.80	100.00	150,328	32.27	12.73	38.86
7	45.01	24.82	5.82	42.30	100.00	295,797	32.09	12.84	32.60
8	12.51	3.81	4.97	11.31	100.00	156,194	9.67	7.10	41.77
9	25.94	10.15	7.23	21.37	100.00	82,541	13.72	5.90	32.22
10	34.62	1.54	8.77	22.02	100.00	69,546	1.03	18.47	21.6
11	22.31	7.15	4.89	16.20	100.00	220,252	11.72	8.40	20.06
12	13.85	2.38	5.13	9.79	99.64	235,056	4.84	4.72	26.69
13	36.34	12.79	3.59	30.75	99.92	104,283	14.35	19.15	20.13
14	25.20	4.69	7.21	17.46	99.86	158,576	5.61	9.93	35.16
15	15.27	1.80	3.06	11.44	100.00	104,771	4.05	13.14	19.91
16	8.11	0.90	1.73	5.38	100.00	73,378	5.55	7.16	18.98
17	46.26	0.98	25.04	19.83	100.00	132,030	0.42	4.80	42.58
18	51.85	1.72	40.06	19.29	100.00	60,957	1.12	3.43	46.38

Table E-13. Raw data for stressor indicators used in Scenario 3

Subbasin ID	% Ag. Area	% Impervious Cover	% Urban Area	# of Septic Systems	# of WWTF and SW Permits	Corridor % Impervious	Corridor % Urban	Corridor % Ag.	Corridor # Road Crossings
1	65.04	0.25	0.85	2,556	3	0.03	0.25	32.89	1181
2	41.09	0.20	0.87	1,459	1	0.03	0.29	16.70	678
3	34.92	0.03	0.16	495	0	0.00	0.18	18.90	439
4	50.13	0.58	1.98	768	3	0.15	0.67	18.77	234
5	62.11	0.22	0.80	2,464	4	0.02	0.29	22.81	1046
6	23.52	0.01	0.11	894	0	0.00	0.09	9.07	577
7	51.69	0.01	0.10	846	1	0.00	0.21	15.27	483
8	82.96	0.06	0.36	1,043	3	0.02	0.27	37.78	312
9	68.99	0.16	1.01	545	2	0.05	0.18	28.32	91
10	57.62	1.47	2.76	287	29	0.07	0.48	50.61	122
11	74.22	0.01	0.20	1,548	12	0.05	0.13	45.94	346
12	79.29	0.40	1.51	2,079	9	0.16	1.03	49.91	544
13	58.53	0.21	0.60	1,193	2	0.00	0.16	43.40	121
14	70.96	0.08	0.23	484	0	0.04	0.23	35.29	227
15	75.42	2.36	4.25	929	2	0.42	1.11	53.53	168
16	71.32	0.91	2.32	734	2	0.19	0.76	58.92	79
17	48.13	0.50	1.51	595	9	0.21	1.34	32.77	104
18	39.19	1.10	2.54	72	22	0.39	2.51	16.89	116

Table E-14. Raw data for social indicators used in Scenario 3

Subbasin ID	% of Total Stream Miles Assessed	Subbasin Population
1	9.45	10,650
2	7.37	8,782
3	2.39	964
4	38.10	7,993
5	4.41	8,229
6	9.75	1,336
7	2.89	2,114
8	31.29	4,416
9	20.32	3,184
10	0.00	1,749
11	5.30	2,186
12	15.15	21,335
13	1.12	3,874
14	17.24	1,356
15	0.00	29,266
16	0.00	9,602
17	8.61	2,307
18	0.00	2,697

Table E-15. Scenario 3 RPS tool screening indicator scores and rankings

Subbasin ID	Ecological Index	Ecological Rank	Stressor Index	Stressor Rank	Social Index	Social Rank	RPI Score	RPI Rank
1	44.46	13	53.28	16	29.50	6	40.22	13
2	62.47	4	29.07	8	23.45	7	52.29	5
3	64.22	3	10.58	1	3.15	16	52.26	6
4	33.88	16	28.18	6	62.40	1	56.03	2
5	61.30	5	50.18	15	18.65	9	43.26	11
6	80.38	1	11.71	2	13.45	12	60.71	1
7	71.83	2	19.88	3	5.90	15	52.62	4
8	46.17	9	34.87	10	47.15	4	52.82	3
9	45.76	10	25.42	5	30.55	5	50.30	7
10	44.91	12	48.08	14	1.40	18	32.74	18
11	45.35	11	43.27	12	9.10	13	37.06	15
12	13.99	18	59.09	18	55.90	2	36.93	16
13	46.99	8	28.56	7	6.60	14	41.68	12
14	37.51	15	21.96	4	23.35	8	46.30	8
15	38.15	14	54.63	17	50.00	3	44.50	10
16	31.25	17	43.72	13	15.25	10	34.26	17
17	51.69	7	30.72	9	13.65	11	44.88	9
18	54.10	6	37.97	11	3.05	17	39.73	14

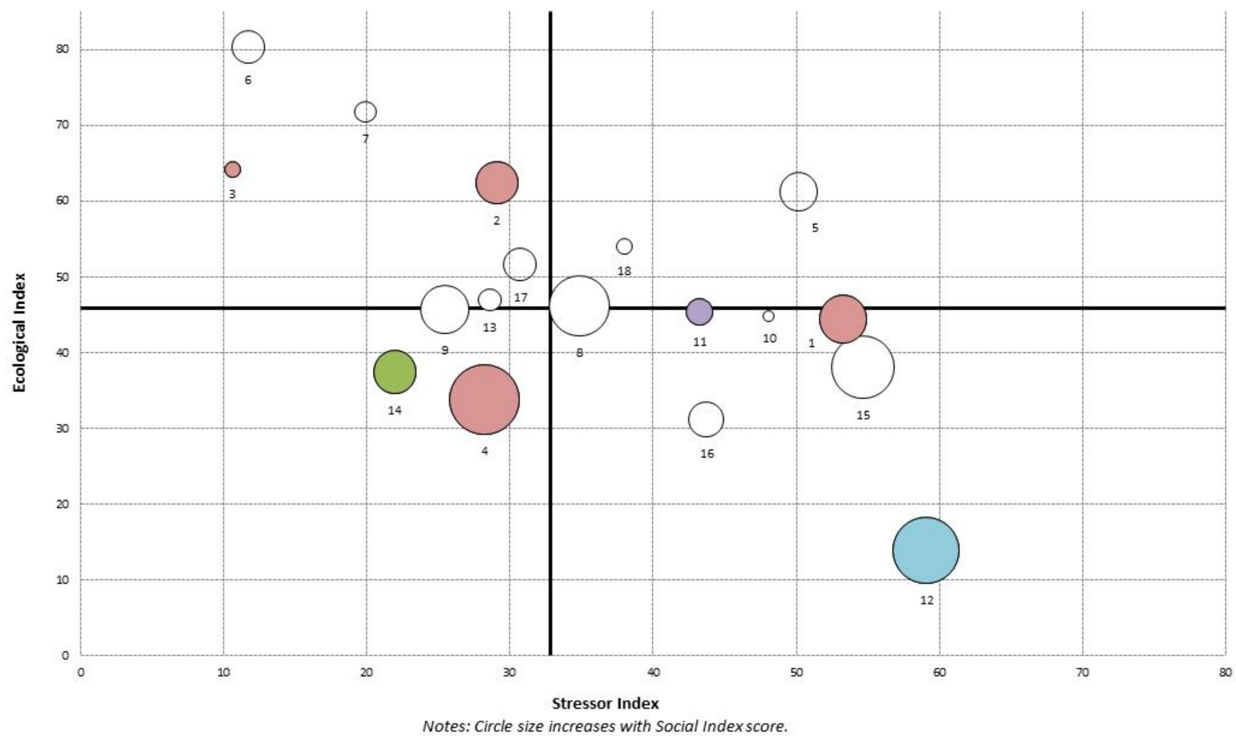


Figure E-5. Scenario 3 bubble plot showing overall RPI ranking of individual subbasins (Shaded bubbles are impaired waters, see Table 1 for description)

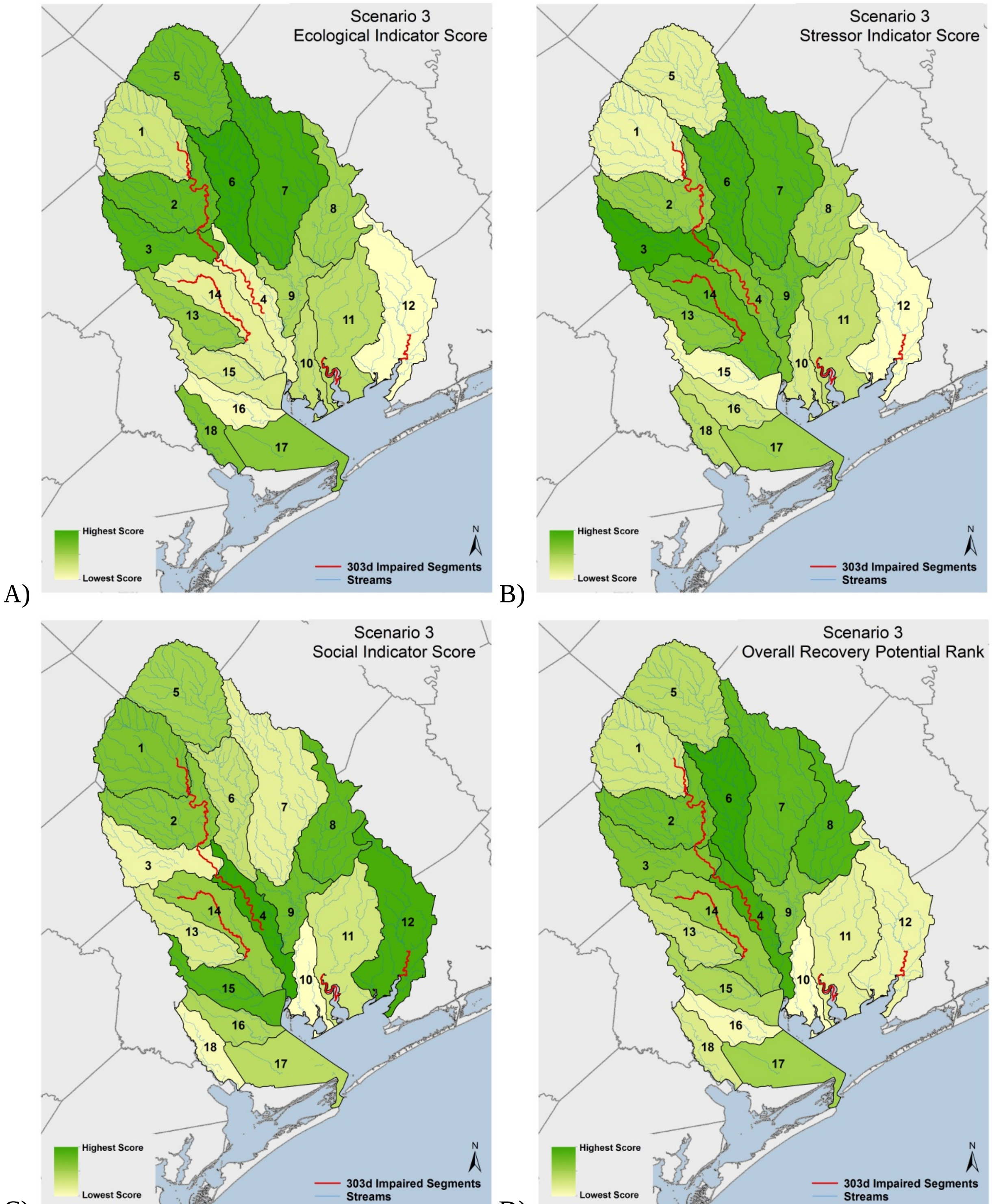


Figure E-6. Scenario 3 ecological (A), stressor (B), social (C) and recovery potential index (D) rankings

Scenario 4

Table E-16. Indicators included in RPS Tool Scenario 4 assessment

Ecological Indicators	Weight Applied	Stressor Indicators	Weight Applied	Social Indicators	Weight Applied
% of Natural Cover	1	% Ag. Land Use	1	% of Stream Miles Assessed	1
% Forests	1	% Impervious Cover	1	Population	1
% Wetlands	1	% Urban	1		
% Woody Veg.	1	# of subbasin OSSFs	5		
% Unimpaired Stream Length	3	# of WWTF/SW Permits	3		
Subbasin Size (Acres)	1	Corridor % Impervious Cover	1		
Corridor % Forest	1	Corridor % Urban	1		
Corridor % Woody Veg.	1	Corridor % Ag.	1		
Corridor % Wetland	1	Corridor # Road Crossings	1		

Table E-17. Raw data for ecological indicators used in Scenario 4

Subbasin ID	% Natural Cover	% Forest Area	% Wetland Area	% Woody Veg.	% of Streams Unimpaired	Subbasin Size Total (Acres)	Corridor % Forest	Corridor % Woody Veg.	Corridor % Wetland
1	28.17	8.08	3.85	25.67	99.84	198,400	15.46	20.17	26.89
2	53.27	28.68	7.89	49.50	99.88	166,300	30.75	11.85	37.08
3	60.56	31.32	7.65	56.36	99.90	123,151	30.44	16.28	30.59
4	42.47	14.79	12.85	34.22	99.73	94,510	8.97	6.24	39.77
5	31.18	11.93	7.42	29.30	100.00	212,173	23.02	13.46	36.18
6	71.85	42.51	8.66	67.80	100.00	150,328	32.27	12.73	38.86
7	45.01	24.82	5.82	42.30	100.00	295,797	32.09	12.84	32.60
8	12.51	3.81	4.97	11.31	100.00	156,194	9.67	7.10	41.77
9	25.94	10.15	7.23	21.37	100.00	82,541	13.72	5.90	32.22
10	34.62	1.54	8.77	22.02	100.00	69,546	1.03	18.47	21.6
11	22.31	7.15	4.89	16.20	100.00	220,252	11.72	8.40	20.06
12	13.85	2.38	5.13	9.79	99.64	235,056	4.84	4.72	26.69
13	36.34	12.79	3.59	30.75	99.92	104,283	14.35	19.15	20.13
14	25.20	4.69	7.21	17.46	99.86	158,576	5.61	9.93	35.16
15	15.27	1.80	3.06	11.44	100.00	104,771	4.05	13.14	19.91
16	8.11	0.90	1.73	5.38	100.00	73,378	5.55	7.16	18.98
17	46.26	0.98	25.04	19.83	100.00	132,030	0.42	4.80	42.58
18	51.85	1.72	40.06	19.29	100.00	60,957	1.12	3.43	46.38

Table E-18. Raw data for stressor indicators used in Scenario 4

Subbasin ID	% Ag. Area	% Impervious Cover	% Urban Area	# of Septic Systems	# of WWTF and SW Permits	Corridor % Impervious	Corridor % Urban	Corridor % Ag.	Corridor # Road Crossings
1	65.04	0.25	0.85	2,556	3	0.03	0.25	32.89	1181
2	41.09	0.20	0.87	1,459	1	0.03	0.29	16.70	678
3	34.92	0.03	0.16	495	0	0.00	0.18	18.90	439
4	50.13	0.58	1.98	768	3	0.15	0.67	18.77	234
5	62.11	0.22	0.80	2,464	4	0.02	0.29	22.81	1046
6	23.52	0.01	0.11	894	0	0.00	0.09	9.07	577
7	51.69	0.01	0.10	846	1	0.00	0.21	15.27	483
8	82.96	0.06	0.36	1,043	3	0.02	0.27	37.78	312
9	68.99	0.16	1.01	545	2	0.05	0.18	28.32	91
10	57.62	1.47	2.76	287	29	0.07	0.48	50.61	122
11	74.22	0.01	0.20	1,548	12	0.05	0.13	45.94	346
12	79.29	0.40	1.51	2,079	9	0.16	1.03	49.91	544
13	58.53	0.21	0.60	1,193	2	0.00	0.16	43.40	121
14	70.96	0.08	0.23	484	0	0.04	0.23	35.29	227
15	75.42	2.36	4.25	929	2	0.42	1.11	53.53	168
16	71.32	0.91	2.32	734	2	0.19	0.76	58.92	79
17	48.13	0.50	1.51	595	9	0.21	1.34	32.77	104
18	39.19	1.10	2.54	72	22	0.39	2.51	16.89	116

Table E-19. Raw data for social indicators used in Scenario 4

Subbasin ID	% of Total Stream Miles Assessed	Subbasin Population
1	9.45	10,650
2	7.37	8,782
3	2.39	964
4	38.10	7,993
5	4.41	8,229
6	9.75	1,336
7	2.89	2,114
8	31.29	4,416
9	20.32	3,184
10	0.00	1,749
11	5.30	2,186
12	15.15	21,335
13	1.12	3,874
14	17.24	1,356
15	0.00	29,266
16	0.00	9,602
17	8.61	2,307
18	0.00	2,697

Table E-20. Scenario 4 RPS tool screening indicator scores and rankings

Subbasin ID	Ecological Index	Ecological Rank	Stressor Index	Stressor Rank	Social Index	Social Rank	RPI Score	RPI Rank
1	44.46	13	53.65	17	29.50	6	40.10	13
2	62.47	4	29.83	10	23.45	7	52.03	7
3	64.22	3	10.51	1	3.15	16	52.29	6
4	33.88	16	25.13	6	62.40	1	57.05	2
5	61.30	5	50.57	16	18.65	9	43.13	11
6	80.38	1	14.05	2	13.45	12	59.93	1
7	71.83	2	17.74	4	5.90	15	53.33	4
8	46.17	9	28.27	8	47.15	4	55.02	3
9	45.76	10	19.33	5	30.55	5	52.32	5
10	44.91	12	44.93	14	1.40	18	33.79	18
11	45.35	11	41.00	13	9.10	13	37.82	15
12	13.99	18	56.55	18	55.90	2	37.78	16
13	46.99	8	25.95	7	6.60	14	42.55	12
14	37.51	15	16.08	3	23.35	8	48.26	8
15	38.15	14	47.75	15	50.00	3	46.80	9
16	31.25	17	35.46	11	15.25	10	37.01	17
17	51.69	7	29.61	9	13.65	11	45.24	10
18	54.10	6	38.28	12	3.05	17	39.62	14

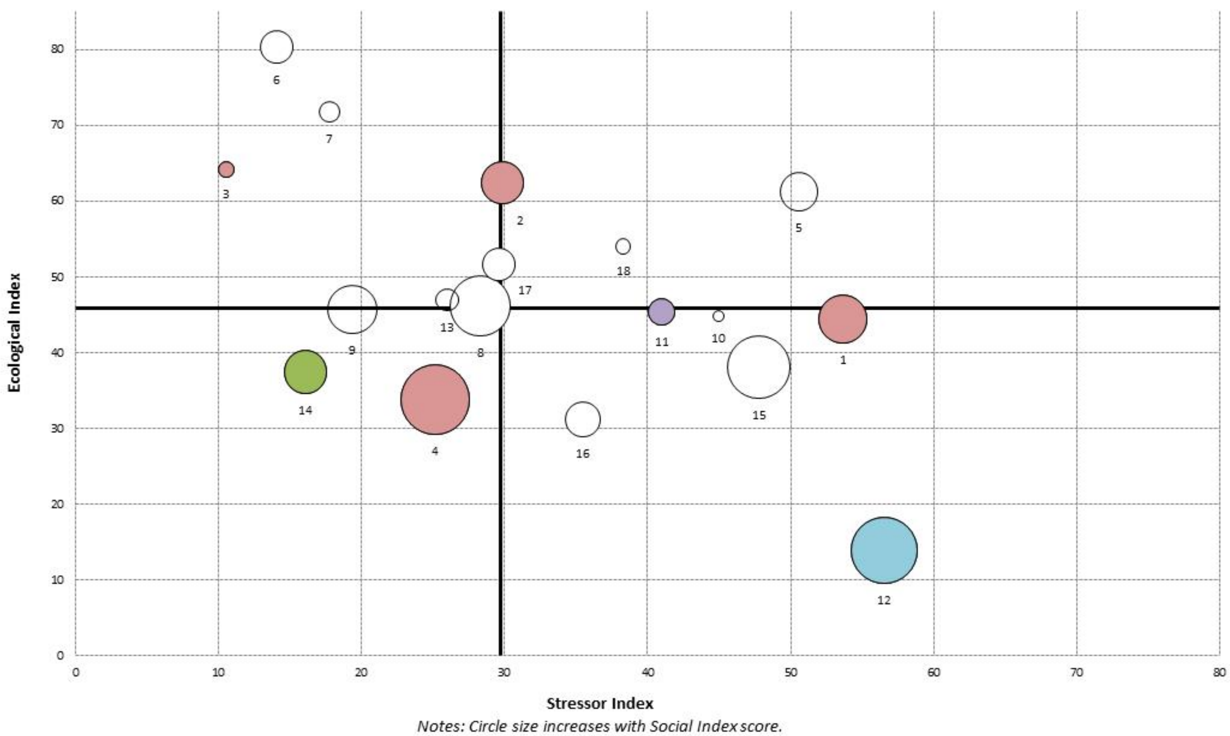


Figure E-7. Scenario 4 bubble plot showing overall RPI ranking of individual subbasins (Shaded bubbles are impaired waters, see Table 1 for description)

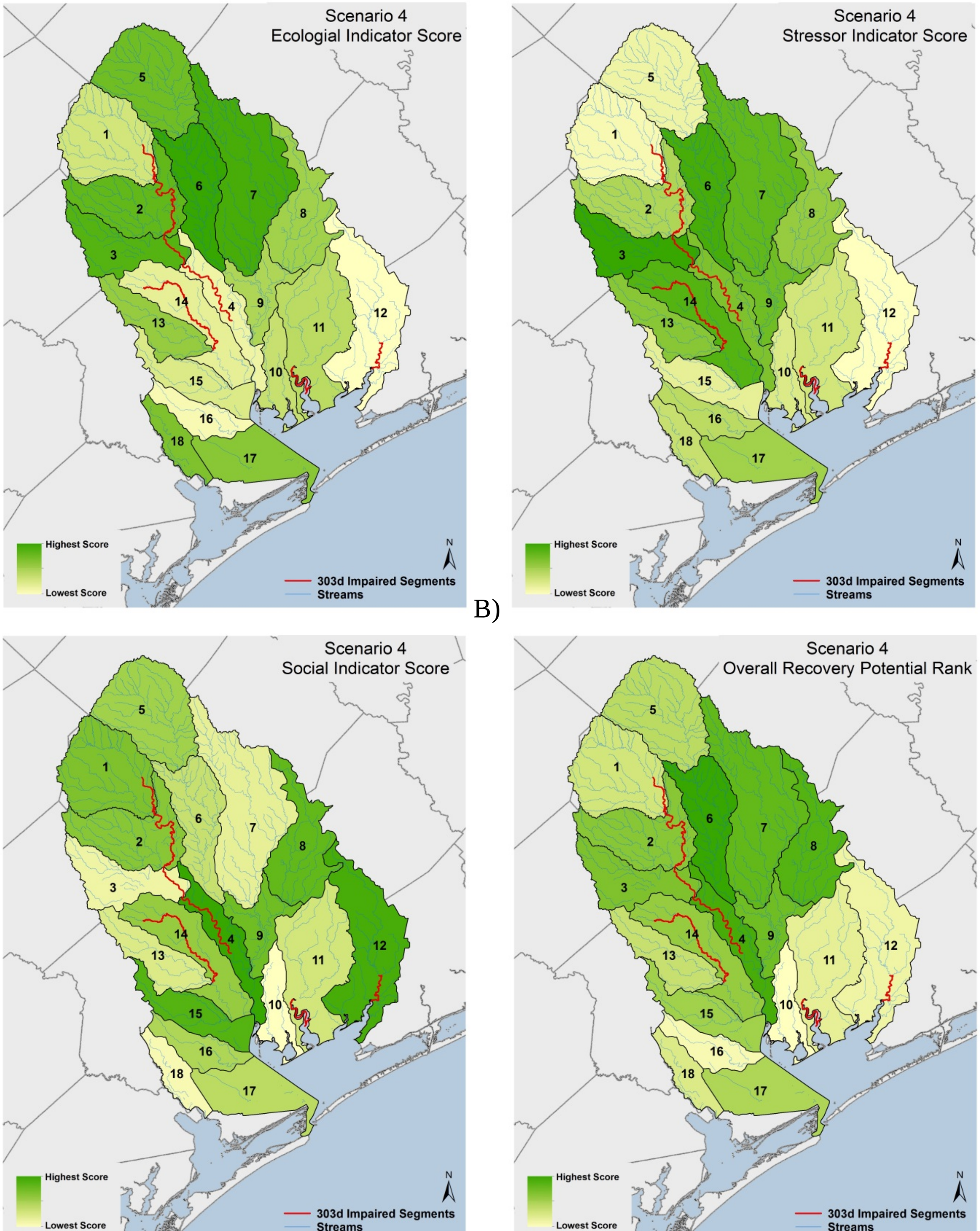


Figure E-8. Scenario 4 ecological (A), stressor (B), social (C) and recovery potential index (D) rankings