Contextual Narrative for Coastal Performance Indicators
Lake Ontario and the Upper St. Lawrence River

This contextual narrative has been prepared for six Coastal Performance Indictors (PIs) on Lake Ontario and the Upper St. Lawrence River: Erosion, Existing Shore Protection, Sediment Budgets, Flooding, Beach Access and Barrier Beaches and Dunes.

1. General Socioeconomic Context

The Coastal Technical Working Group (CTWG) has developed an extensive database to complete the impact evaluation for the six Performance Indicators (Coastal Data Server, active). In addition to spatial datasets, such as 3D topographic grids and temporal information, such as hourly wave data along the shoreline, a comprehensive property parcel database has been developed for a buffer zone along the shoreline of 100 to 200 m, depending on the local hazards and site conditions. The parcel database includes over 22,000 property parcels. This dataset, extensive field work, and the four year technical investigation were used to provide background data for this contextual narrative. Information on the general socioeconomic context is listed below:

a. Production Value of Interest: Several tracks of shoreline are not covered in the parcel database due to a lack of digital parcel data, such as the City of Toronto, County of Prince Edward, Bay of Quinte and much of the Canadian shoreline for the Upper St. Lawrence River. Therefore, based on a general knowledge of these areas and the existing 22,000 parcels in the database, we estimate that there are over 25,000 privately owned riparian properties on Lake Ontario and the Upper River exposed to coastal hazards. The assessed value of this property is approximately 5 billion dollars. This dollar estimate is based on the actual data plus the projections for the areas with missing information. It does not include county or municipal holdings, such as water treatment plants, or state/federal operations such as nuclear plants. If the tax contribution by these riparian properties to local, state/provincial and federal governments were added to the assessed value of the land/buildings, the overall production value would likely increase by 30 to 50 percent, for a total production value of 6.5 to 7.5 billion dollars.

   The production value of beach recreation can be measured in terms of annual expenditures. For the beaches with visitation statistics (generally state and provincial parks), the annual expenditures associated with beach use exceed 100 million dollars. Considering there are many beaches not included due to the lack of visitation statistics, such as municipal beaches, the actual expenditures or productive value of beaches on Lake Ontario and the Upper St. Lawrence River is likely 50 to 100% higher.

   Barrier beaches and dunes are an integral physical component of the sheltered embayments and drowned river valleys along the shores of Lake Ontario, which in turn support wetlands and estuaries that provide critical environmental habitat. Refer to the Barrier Beaches and Dunes Performance Indicator summary for additional information. Since a productive value is not placed on the environmental habitat and the species it supports, it is not possible to assign a productive value to barrier beaches or dunes. However, it is critical to note they play a valuable role in maintaining estuaries and wetlands, and by extension water level impacts on these physical features should be considered.

   In summary, the overall productive value of the coastal performance indicators is 6.7 to 7.7 billion dollars, which excludes the benefits of barrier beaches on the natural environment.

b. Number of Stakeholders: With over 25,000 riparian properties affected by water level fluctuations, erosion, flooding and shore protection impacts have direct impacts on over 50,000 people in Ontario and New York State. Since State and Provincial beaches are owned by the residents of New York State and Ontario, the entire population of these two political units are stakeholders. Further, when the environmental benefits of barrier beaches

and dunes on ecosystem health and biodiversity are considered, the stakeholders extend to at least everyone living within the watersheds that supply Lake Ontario and the Upper St. Lawrence River.

c. Organizational Characteristics: There are no organizational characteristics of these stakeholders that are relevant to this contextual narrative.

d. Values and Perceptions of Stakeholders: Riparian property is held around the entire perimeter of the lake and river. It is not possible to list all values and perceptions of these stakeholders, however, some very general observations are provided: i) low to average lake levels are desired, ii) high lake levels are not desired because they will increase flood risk, accelerate erosion, and result in damage to existing shoreline protection, and iii) more could and should be done to regulate the lake for the benefit of riparian interests. Further, many riparian land owners feel the lake levels since regulation are higher than they would have been without the dam, when, in reality, they are lower than a no-project scenario.

e. Statutory, Regulatory and Policy Restrictions: Land use zoning and shoreline regulations influence development patterns and growth rates within the coastal hazard zone of Lake Ontario and the St. Lawrence River. Under the status quo, conversion of agricultural lands to residential parcels will continue and the number of property parcels at risk to coastal hazards will increase in the future. Thus, the estimate of 25,000 riparian parcels will increase in the future.

   The Province of Ontario recently introduced Greenbelt Legislation for the western end of Lake Ontario, which will stop the conversion of agricultural lands to residential land use in this region. The impacts of this legislation on future growth rates of coastal riparian property will be relatively small though, as much of the shoreline is already zoned residential in this region. In summary, future land use zoning is not expected to change and the number of riparian properties is expected to increase on the lake and river.

   A second regulatory consideration is the construction of shoreline protection to reduce or eliminate erosion and flooding hazards along the shoreline. Although State, Provincial and Federal agencies don't necessary condone the construction of engineering structures to protect residential properties, permits can be obtained. For example, on the open coast of Lake Ontario, approximately half of the riparian parcels are already armored. If changes were made to the policies governing the construction of new shoreline protection or the maintenance of existing structures, there would be significant impacts on the riparian land owners within the study area.

f. History of Interest: At the turn of the 20th Century, residential waterfront properties were generally located in urban centers. Between the urban centers, the shoreline lands were used for agriculture or natural open spaces, such as parks. In the past 100 years the population in the Great Lakes Basin has increased significantly and so has the wealth in the economy. Combined, these two forces have resulted in a steady conversion of rural agricultural lands to riparian property. Initially, the focus of these converted lands along the waters edge was cottage or seasonal properties. However, in the last several decades many of the seasonal properties have been converted to full time residences. In addition, vast tracts of agricultural land have been converted into residential estate lots.

   With the current land use policies in Canada and the United States, pressure to convert agricultural or rural lands to residential properties will likely continue until the entire shoreline is developed into urban communities. This is referred to as the "build out date", which corresponds to the time in the future when the entire shoreline features either residential development, commercial - industrial lands or designated park lands. This topic is discussed further in Section 5 below.

g. Market Conditions: Market demand for additional residential property will continue, as mentioned above, until no undeveloped land remains along the shoreline. Therefore, the economic impact calculations computed with the Flood and Erosion Prediction System (FEPS) and the Shared Vision Model (SVM) will under estimate the actual damages in the

future. In other words, our database of shoreline development is current as of 2003/2004. In 50 years, there will be more development but our database will not reflect this additional growth. The vulnerability of future development to damage will be strongly influenced by the enactment and enforcement (or lack thereof) of shoreline management policies.

h. Impacts of High and Low Lake Levels: 1973 is one of the most frequently mentioned high water years when discussions are held with riparian land owners in the field. During the high water conditions since regulation, such as 1973 and 1992, the riparian community suffered significant economic damages. The impacts included accelerated shore erosion, increased frequency of flooding, and storm damage of existing shoreline protection structures. A report published by the Ministry of Natural Resources (Water Network, 1991) documents historical river and lake flooding in the Province of Ontario and supports the findings of our algorithms. Namely, the months of March and April are the most damaging for lake flooding. Also, there was relatively good agreement between the historical accounts of flood damages reported for Lake Ontario based on newspaper articles and the results generated with the FEPS.

   Many long term riparian land owners remember the low lake levels on the mid 1960's. This is often viewed as the utopian condition, with wide beaches in front of eroding bluffs and seawalls, and no threat of flooding. Natural beaches were wide and aeolian transport was able to build new sand dune systems. These low levels are desired by the riparian community, and in general, make them the happiest.

2. Performance Indicators

The coastal performance indicators for Lake Ontario and the Upper St. Lawrence River are listed, along with important assumptions and data limitations:

a. Erosion Performance Indicator: This performance indicator quantifies the impacts of shore erosion on riparian property and public infrastructure (e.g. industrial buildings) located along the shoreline, in embayments and on the river. The algorithm assumes the owner will build shoreline protection prior to erosion actually threatening the home. The economic cost of building the shoreline protection is a liability to the land owner. The major assumption of the economic methodology is that government agencies will continue to issue permits to construction shoreline protection.

b. Shore Protection Performance Indicator: Water level impacts on existing shoreline protection structures are quantified with this performance indicator. During periods of high lake levels and storms, the algorithm predicts structure failures due to wave overtopping, undermining and degradation (age). The economic impacts are measured in terms of the cost to upgrade/replace the damaged structure. If agencies stopped issuing shoreline protection permits, the economic function would overestimate structure replacement costs. However, the damage would ultimately be transferred to the building(s) in the form of destruction due to erosion (i.e. home falls over the bank) and this process is not quantified in our algorithm.

c. Sediment Budget Performance Indicator: This performance indicator was developed for educational purposes and no economic function was developed to quantify water level impacts on sediment budgets.

d. Flooding Performance Indicator: The impacts of water levels and storm waves on flood levels and the associated economic damages are quantified with the Flooding Performance Indicator. The computer algorithm can be run in two different modes: i) with mitigation, which assumes the land owner will eventually mitigate flood risks if they are repetitive, and ii) without mitigation, which assumes the owner will sustain flood damage and continuously repair the damage and replace the contexts to full value. The Plan Formulation and Evaluation Group and the Economic Advisory Group will determine which method is most appropriate for the study calculations.

e. Beach Access Performance Indicator: The Beach Access PI quantifies the impacts of water levels on the physical conditions of recreational beaches, namely beach width, and the associated impacts on beach visitation at state and provincial parks. The field data collected indicated that beach width would affect visitation and ultimately economic expenditures. Of course, other factors not related to water level regulation, such as weather, will affect visitation. The algorithm only considers the impacts of water levels on visitation, as it is the only factor affected by regulation.

f. Barrier Beaches and Dunes Performance Indicator: The principal component of the beach and dune PI is to highlight the important relationship between water levels and erosion/sedimentation cycles. For example, during high lake levels, barriers and dunes will be susceptible to erosion and migration inland. Conversely, during periods of low lake levels, beaches, dunes and barrier systems can recover naturally due to onshore sediment transport and aeolian processes (wind blown sand). There is no algorithm or economic calculation for this PI.

For the Erosion, Shore Protection and Flooding PI, the scale for the assessment was the individual property parcel, while the economic results are reported on a county, country or system wide scale. Since digital property parcels were not available for a few geographic regions of Lake Ontario and the Upper St. Lawrence River, the total economic benefits or costs will be an underestimate of the actual impacts. Therefore, when comparing the dollar impacts, the results from the Coastal PIs should be considered conservative.

The computer algorithms developed for the Erosion, Flooding and Shore Protection Performance Indicators were based on four years of detailed study and data collection, peer reviewed throughout the development process and extensively documented in the three Baird reports listed in the sources below (2004_a to 2004_c). The reader is referred to these documents for additional information on modeling assumptions.

3. Potentially Significant Benefit Categories Not Addressed by the Current Performance Indicators (secondary impacts)

Several benefits and impacts of water levels not addressed by the current performance indicator algorithms in the SVM are summarized below:

a. For the Erosion PI, in addition to the cost of constructing shoreline protection to mitigate erosion, a regulation plan that accelerates erosion reduces the actual footprint of a land parcel and thus the available land area. This reduction in parcel size is not quantified by an economic calculation, nor reflected in assessed property values. However, it does represent a secondary impact to riparian property owners;

b. With the Shore Protection Performance Indicator, structure maintenance and replacement following a failure results in larger and higher structures. Not only are these structures more expensive to construct, in some locations the ever increasing crest elevation may impair the visual amenities of a property. In other words, if you can't see the lake from your family room, there is no incentive to pay extra for a waterfront parcel;

c. Following a flood event, there are many additional secondary impacts such as temporary loss of residence, required leave from work to repair/restore the home and other negative economic spin-offs. These secondary impacts are not quantified with the current methodology; and

d. As mentioned previously, there are no economic calculations associated with the Barrier Beach and Dune PI, only recommendations for new criteria. The benefits of increasing the frequency and duration of low lake levels will not be summarized in any economic tables; however there will be significant benefits to beach-dune systems and the environmental habitat they provide and protect.

4. Key Baseline Conditions

There are two key baseline conditions related to riparian property around the perimeter of Lake Ontario and the St. Lawrence River, as defined by the digital property parcel database. First, development permits will continue to be granted for privately held land. In other words, land owners will be able to develop waterfront parcels for residential and commercial endeavors. This trend will likely continue, and as such, because development controls are weak or inadequate in some jurisdictions, future homes will be constructed too close to the waters edge and be subjected to coastal hazards. In short, the number of parcels at risk will increase in the future.

The second key baseline condition relates to the current approach for addressing water level hazards for two of the Coastal PIs: Erosion and Existing Shoreline Protection Structures. The economic methods for these two PIs include adaptive behavior in the form of engineering solutions. In other words, when evaluating a new potential regulation plan in simulation time (hypothetical time in the future for the computer models), if erosion is threatening a home because a plan features high lake levels, our economic methods assume the owner will mitigate the hazard by building new shoreline protection. They won't let their investment (i.e. home) fall into the lake because this loss is significantly greater than the cost associated with building new shoreline protection or upgrading existing protection. It is assumed that new, upgraded, or replacement shore protection will be well-engineered, with a design life of 25 years.

As mentioned above, securing a permit to build shoreline protection along the waterfront is a complicated, lengthy and expensive proposition. However, if the riparian perseveres, often with the assistance of a Professional Engineer, a permit can be successfully obtained.

If the regulatory process is altered or changes such that a riparian land owner can no longer protect their property from coastal hazards with engineered structures, the predicted economic damages for high lake levels will increase dramatically. Rather than incurring the cost of building a $20,000 to $40,000 seawall to protect a riparian dwelling, the owner may lose a $200,000 building because of erosion and flooding damages. Therefore, the current economic methods developed in the FEPS and linked to the SVM would significantly under-estimate the impacts of high lake levels under this scenario.

In summary, there are two key baseline conditions or assumptions for the Coastal PIs. First, riparian land owners now live in coastal hazard areas, and future development of new parcels for residential or commercial uses will likely increase the number of properties at risk. Second, the riparian land owners will be permitted to mitigate coastal hazards with engineered protection. In other words, a shoreline protection structure is less costly than losing the entire home, and this is generally the desired approach for the riparian land owner.

5. Key Trends

The Coastal Technical Working Group has prepared a comprehensive report on existing and future land use trends entitled: "A Summary of Existing Land Use Management Policies Along the Lake Ontario – St. Lawrence River Shoreline: Implications for Future Water Level Management", (CJSC, 2004). Some key findings of this report are summarized in the bullets below:

a. Residential land use occupies approximately 60% of the Lake Ontario and Upper St. Lawrence River shoreline. In some of the developed Counties, such as Monroe on the south east shore, the percentage of developed property is much higher at almost 90%;

b. The increase in shoreline development along the Lake Ontario shoreline for the decade from 1990 to 2000 was approximately 6%. There is every indication this decadal growth rate will continue in the future until no undeveloped land is available;

c. On the south shore of Lake Ontario, the detailed US parcel data indicated the average new house size has almost doubled in the last 10 years compared to all previous development. It is not surprising that the assessed values of the homes constructed in the last ten years have also doubled. Although detailed data were not available to complete a similar analysis in Ontario, the observed trends are very similar. Collectively this land use trend is referred to as "Mansionization". New estate homes are being constructed amongst smaller cottage settlements or smaller homes are torn down and replaced by an estate home;

d. With this rapid pace of development, some Counties will reach their maximum development potential in the next 30 years, such as Niagara, Orleans and Monroe in NY State. Others such as Halton, Peel and Toronto in Ontario have already reached their development maximum (or, are very close). In other words there are no open tracks of land to be converted to residential communities. In some of the more rural locations, growth can be facilitated for the next 100 years and these will be the areas experiencing the most development pressure; and

e. With the ever increasing urban densities and sprawl around the lake and river, the value of public open space and recreational opportunities along the coast will increase. This urban pressure will intensify the use of beaches for recreational opportunities and these facts highlight the importance of the Beach Access and Barrier Beaches and Dunes PIs.

In summary, the trend for riparian land and residential development is continued rapid growth and increases in the size and value of new home construction. One implication for the IJC water levels study is the impact of the static property parcel database, which will under estimate future economic impacts as development densities increase and the value of existing real estate escalates. However, regardless of these limitations, the database of existing development will be sufficient to identify the plans that cause the most benefits and costs based on the current conditions. During the design of our study, the Coastal TWG determined it was more important to accurately record and catalog the existing development patterns than to forecast future growth. The anticipated growth, in turn, will make the recreational experiences associated with beaches even more valuable in the future.

6. Expected Consequences of Changes

The Erosion, Flooding and Shore Protection PIs collectively quantify water level impacts on the built environment. In other words, the natural shoreline conditions have been altered or heavily modified by the riparian land owners for their enjoyment and often to protect themselves from coastal hazards, such as erosion and flooding. The protection in most cases is in the form of structural solutions, such as engineered seawalls and rock revetments. In some cases, these structures have been carefully designed to account for the historic range of lake levels since regulation (i.e. 1960 to present). In other instances, a design professional was not consulted and the solution was based on local knowledge and experience. Regardless of whether the protection was well engineered or poorly designed, it was meant to address the driving forces (i.e. storm waves) and the historical range of lake levels since regulation (in most cases).

If significant changes are made to the operating range of Lake Ontario, such as increasing the upper limit or the frequency of high levels during the spring storm season, the level of protection from the existing physical infrastructure will be reduced. In other words, a seawall designed to protect a property from flooding during a storm event in the current operating range will be less effective during water levels at 76.0 m (249.3 ft), for example.

In short, there is significant development in coastal hazard areas on Lake Ontario and the Upper St. Lawrence River. Many of the riparian land owners attempt to mitigate or reduce the hazards with structural protection based on the lake level trends since regulation. An increase in the frequency, duration or magnitude of high lake levels in the future under a new regulation plan will magnify the many challenges front row developments already face living on the edge of the lake

and river. Conversely, the existing shoreline protection would provide increased benefits if the current upper threshold for the operating range was lowered.

With respect to beaches and dunes, the current regulation plan (1958D) and adopted deviations has reduced the natural range of fluctuations on Lake Ontario. While the reduction of high lake levels has reduced erosion rates for sandy shorelines, this stability also negatively impacts dune grass communities, which require occasional disruption. Attempts to eliminate periods of low lake levels benefits commercial navigation and recreational boating, however, it deprives these natural sandy shorelines from their period of rejuvenation due to enhanced aeolian activity and beach recovery. The following bullets provide some insight into the expected consequences of changes in the regulation of Lake Ontario water levels:

- Increasing the upper limit of the operating range of Lake Ontario will accelerate beach and dune erosion, and threaten the stability of barrier beaches. These are dynamic sandy systems and hard structural engineering will not mitigate the effects of higher lake levels;
- Decreasing the lower limit of the operating range or increasing the frequency of low lake levels would provide benefits for beaches, dunes and barrier complexes. However, it is not possible to quantify these benefits with dollars in the Shared Vision Model; and
- Utilizing the existing regulation plan and further suppressing the natural range of Lake Ontario will reduce the potential for natural recovery of these beaches. Some of these impacts could be mitigated with large scale beach nourishments but these projects are costly and not common on Lake Ontario.

7. Adaptive Behaviors:

The following bullets describe adaptive behavior for the six Coastal Performance Indicators (where applicable):

a. Erosion Performance Indicator: The entire economic methodology for this PI is predicated on adaptive behavior. Riparian land owners don't let their homes fall into the lake – they build shoreline protection. The prevalence of shore protection (approximately 50% of lake parcels armored) justifies the selection of this methodology;

b. Shore Protection Performance Indicator: Again, the entire algorithm for existing shore protection is based on adaptive behavior. When a structure fails or no longer provides adequate flood and erosion protection, the riparian adapts by upgrading the structure;

c. Sediment Budget Performance Indicator: There is no economic methodology for this PI and thus no adaptive behavior;

d. Flooding Performance Indicator: Property owners who suffer flooding or wave damage might adapt by raising their building, bringing in fill to raise the lot, and/or incorporating shore protection. While it is highly likely that a property owner experiencing erosion will construct shore protection prior to their home falling in the lake, a property owner who is occasionally subject to flooding and waves may experience damages several times prior to adapting. For purposes of this analysis, it was assumed that property owners do not adapt to flooding and wave damage;

e. Beach Access Performance Indicator: When water levels result in an undesirable beach condition, such as a very narrow zone for recreational activities, the most common adaptive behavior is substitution. In other words, alternative recreational alternatives are selected, such as interior camping; and

f. Barrier Beaches and Dunes Performance Indicator: The principal users of the barrier beach and dune ecosystems are flora and fauna (animals and plants). They don't necessary adapt to changing physical conditions, such as an eroding dune system or degraded marsh, but

rather respond to the altered environment. For example, the piping plover no longer nests along the shores of Lake Ontario in sand dune environments because this type of habitat has virtually disappeared. The population has responded by decreasing in size and altered its natural range, which no longer includes Lake Ontario.

8. Risk Assessment/Sensitivity Analysis:

The following bullet points provide some quantitative information on the number of homes at risk to erosion, flooding and damage to existing shore protection structures. The statistics are based on an analysis of the property parcel database, which includes over 22,000 riparian land holdings. In addition, some qualitative comments are provided on water level impacts on beaches and dunes:

a. 578 homes are less than 20 m (65.6 ft) from the shoreline on Lake Ontario. Of these 578 homes, over 200 are less than 10 m (32.8 ft) from the shoreline and 91 are within 5 m (16.4 ft) of the Lake Ontario waterline. Many of these homes are at imminent risk to losses from continued shoreline erosion and flood damages;

b. 7,905 homes were identified with land elevations at or below the 77.2 m (253.3 ft) contour, which was an upper threshold for potential flood damages established by the study. Of this total, 790 have elevations at the base of buildings equal to or less than 75.37 m (247.3 ft), which is the current upper limit of the operating range for Lake Ontario. When lake levels reach or exceed this upper threshold of the existing operating range, as they did in 1973 and 1993, the risk of economic damage to these low lying properties accelerates;

c. The property parcel database identified 6,175 existing shoreline protection structures, such as seawalls and revetments, on Lake Ontario for front row buildings. Of this total, only 5% were Level 1 structures (well engineered and well maintained with a design life of greater than 50 years). Of this 5%, many of the parcels were associated with institutional buildings, such as water treatment facilities, power plants, and marinas. Very few Level 1 structures protect privately owned riparian property and buildings. Therefore, changes to the current operating range in the future, such as more high lake levels, will increase the frequency of maintenance events for the vast majority of these structures protecting riparian property (Level 2 and 3 shoreline protection structures) and decrease their life expectancy. Conversely, low lake levels will extend the life cycle of these existing shoreline protection structures and they will be more effective at minimizing hazards, such as flooding; and

d. There is considerable risk associated with adopting a new regulation plan that does not consider the specific needs of beaches and barrier complexes. First, human interaction with the waters edge may be negatively impacted in the future. Second, since many of the Environmental TWG Performance Indicators rely on the habitat created by barrier beaches, these PIs will also be negatively impacted. And finally, these physical-biological interactions are not quantified in the Shared Vision Model, which makes it imperative that the findings summarized in the Contextual Narratives and PI Summaries be considered when evaluating new potential regulation plans.

Much of the existing coastal community along the shores of Lake Ontario and the Upper St. Lawrence River is located within the coastal hazard zone. The historical range of lake levels since regulation began in 1960 has resulted in economic costs due to erosion, flooding, construction of new structural protection, and maintenance of existing shore protection. Since development pressures are anticipated to increase the number of properties located in the coastal hazard area in the future, higher lake levels will increase economic damages. Lower lake levels, such as the new upper operating range recommended by the Coastal TWG for Lake Ontario, will decrease economic losses and provide benefit to beaches and dunes.

9. Sources:

Baird & Associates, 2004_a. *Shore Protection Performance Indicator: Methodology and Shared Vision Model Application.* Prepared for the IJC Plan Formulation and Evaluation Group, p.1 to p.30.

Baird & Associates, 2004_b. *Erosion Performance Indicator: Methodology and Shared Vision Model Application.* Prepared for the IJC Plan Formulation and Evaluation Group, p.1 to p.27.

Baird & Associates, 2004_c. *Flooding Performance Indicator: Methodology and Shared Vision Model Application.* Prepared for the IJC Plan Formulation and Evaluation Group, p.1 to p.30.

Christian J. Stewart Consulting, 2004. *A Summary of Existing Land Use, Land Use Trends and Land Use Management Policies Along the Lake Ontario – St. Lawrence River Shoreline: Implications for Future Water Level Management.* Prepared for the Coastal Technical Working Group, International Joint Commission.

Coastal Data Server, active. *Maintained and populated by Baird & Associates for the purpose of this study*, owned by the IJC.

The Water Network, 1991. *A Report on Ontario Flood History*. Prepared for the Ontario Ministry of Natural Resources.

10. Review Process:

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Reviewed by: Members of the Coastal Technical Working Group
Received TWG Support: Yes
External Review: