City and Industrial Development Corporation (CIDCO) of Maharashtra, India, is a planning authority for the Navi Mumbai area. It is responsible for the Dronagiri project, one of 14 new nodal townships in the previously undeveloped Dronagiri archipelago. The region typically experiences heavy rainfall from August through November that floods the area completely. To prevent this flooding from occurring once the area is fully developed, CIDCO deployed Bentley’s CivilStorm stormwater modeling and analysis software. CIDCO used CivilStorm to plan a drainage system of interconnected channels that would discharge the runoff from high-intensity storms into holding ponds. These ponds would be equipped with flap gates and outlet structures that would enable them to hold the runoff under the worst tidal conditions. With CivilStorm, CIDCO was able to evaluate the Dronagiri archipelago for overland flows in different regions, examine the channels and holding ponds, simulate water levels in each holding pond under different storm and tidal conditions, and check the adequacy of outlet pipes from the holding ponds.

Topographic Challenges
Dronagiri is located near Jawaharlal Nehru Port, one of India’s largest and most modern seaports. It spans residential and industrial zones as well as a warehousing zone. The 2,700-hectare township borders the Arabian Sea on the north, the Dronagiri Hills on the west, and Karanja Creek on the south.

Topographic data revealed that 99 percent of the area proposed for development was below RL 3.00 meters and the high tide level was 3.25 meters. The ridge lines of Dronagiri Hills indicated that the catchment would drain storm runoff into planned residential areas and a market that would be below high tide. CIDCO adopted the Dutch Method of reclamation, which consists of holding ponds and retention ponds, to provide a stormwater disposal system and avoid flooding. It found this approach to be the most cost-effective.
tide at -0.75 meters. The water in the holding ponds would be discharged into the sea at low tide. But CIDCO needed a way to create the computations to predict the water levels in different holding ponds at different times — for any given tide level as the rainfall progressed — for each revision of the land use plan.

In addition, the holding ponds had to allow water to accumulate during high tides and heavy precipitation, and to allow flow back into the sea at low tide.

Moreover, CIDCO had to consider road levels and surrounding terrain that were directly related to the holding ponds. Engineers also needed to know the land use development plans to determine how much runoff would enter the ponds and calculate their capacity (the runoff will vary depending on land use).

**Holding Ponds Solution Using CivilStorm**

Approximations of water levels using manual calculations or Excel spreadsheets were required, but getting the results, which were often inaccurate, was time consuming.

Using CivilStorm software for stormwater conveyance dynamic modeling, CIDCO’s engineers were able to calculate thousands of iterations in a few seconds and build a stormwater network model of Dronagiri from the catchment to the tidal outfalls. Because the modelers were able to test various scenarios for the modifications of the drainage systems to find out if they were adequate, the model simulated the effects of various changes in the planned drainage system. The software’s dynamic calculations also served as an accurate support tool for crucial decisions regarding the road levels and land development in Dronagiri.

![Figure 2: Holding pond’s hydraulic grade](image)

“The CivilStorm model helped a lot during the planning stage of the project to update the alignment and capacity of various channels and holding ponds according to the changes in land use development plans,” said P.R. Natesh, executive engineer, CIDCO. “The same work would have consumed heavy manpower and time, and getting the results in the desired formats would have been hard to achieve.”

**Environmental and Community Impact**

The CivilStorm software helped CIDCO design and analyze the stormwater infrastructure to protect the Dronagiri archipelago during monsoon season once it is inhabited. Since the start of the project, CIDCO has developed basic infrastructure in the zone, and around 350 hectares (20 percent of the land) have been sold. In addition, around 90 hectares are currently being used for commercial purposes.

Natesh concluded: “Thanks to the efficient and timely use of CivilStorm, which ensured accurate dynamic calculations, CIDCO was able to handle complex hydraulic problems, ensuring Dronagiri would be flood free to the best of its capacity.”