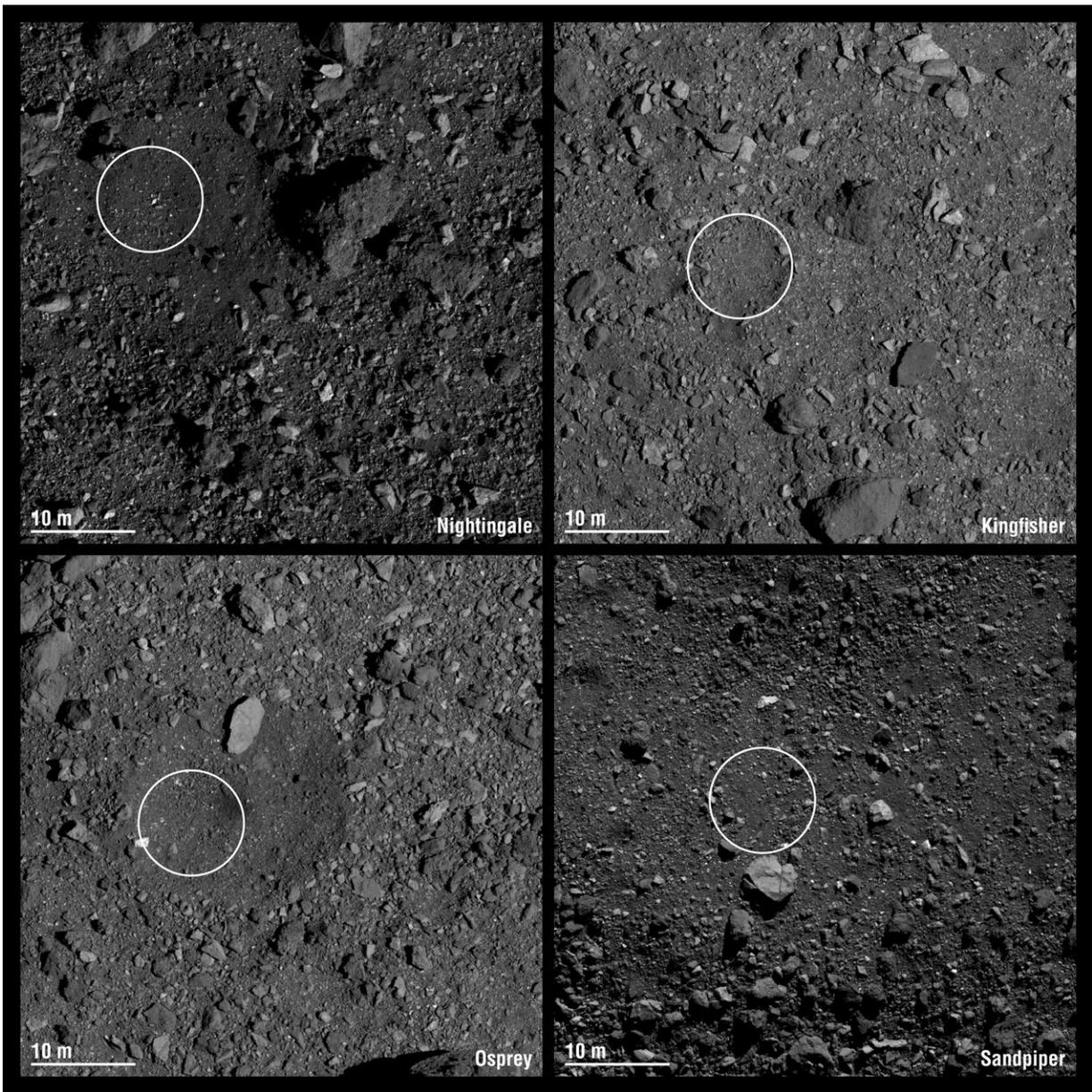


NASA mission selects final four site candidates for asteroid sample return

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Pictured are the four candidate sample collection sites on asteroid Bennu selected by NASA's OSIRIS-REx mission. Site Nightingale (top left) is located in Bennu's northern hemisphere. Sites Kingfisher (top right) and Osprey (bottom left) are located in Bennu's equatorial region. Site Sandpiper (bottom right) is located in Bennu's southern hemisphere. In December, one of these sites will be chosen for the mission's touchdown event. Credit: NASA/University of Arizona

After months grappling with the rugged reality of asteroid Bennu's surface, the team leading NASA's first asteroid sample return mission has selected four potential sites for the Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) spacecraft to "tag" its cosmic dance partner.

Since its arrival in December 2018, the OSIRIS-REx spacecraft has mapped the entire asteroid in order to identify the safest and most accessible spots for the spacecraft to collect a sample. These four sites now will be studied in further detail in order to select the final two sites—a primary and backup—in December.

The team originally had planned to choose the final two sites by this point in the mission. Initial analysis of Earth-based observations suggested the asteroid's surface likely contains large "ponds" of fine-grain material. The spacecraft's earliest images, however, revealed Bennu has an especially rocky terrain. Since then, the asteroid's boulder-filled topography has created a challenge for the team to identify safe areas containing sampleable material, which must be fine enough—less than 1 inch (2.5 cm) diameter—for the spacecraft's sampling mechanism to ingest it.

"We knew that Bennu would surprise us, so we came prepared for whatever we might find," said Dante Lauretta, OSIRIS-REx principal

investigator at the University of Arizona, Tucson. "As with any mission of exploration, dealing with the unknown requires flexibility, resources and ingenuity. The OSIRIS-REx team has demonstrated these essential traits for overcoming the unexpected throughout the Bennu encounter."

The original mission schedule intentionally included more than 300 days of extra time during asteroid operations to address such unexpected challenges. In a demonstration of its flexibility and ingenuity in response to Bennu's surprises, the mission team is adapting its site selection process. Instead of down-selecting to the final two sites this summer, the mission will spend an additional four months studying the four candidate sites in detail, with a particular focus on identifying regions of fine-grain, sampleable material from upcoming, high-resolution observations of each site. The boulder maps that citizen science counters helped create through observations earlier this year were used as one of many pieces of data considered when assessing each site's safety. The data collected will be key to selecting the final two sites best suited for sample collection.

In order to further adapt to Bennu's ruggedness, the OSIRIS-REx team has made other adjustments to its sample site identification process. The original mission plan envisioned a sample site with a radius of 82 feet (25 m). Boulder-free sites of that size don't exist on Bennu, so the team has instead identified sites ranging from 16 to 33 feet (5 to 10 m) in radius. In order for the spacecraft to accurately target a smaller site, the team reassessed the spacecraft's operational capabilities to maximize its performance. The mission also has tightened its navigation requirements to guide the spacecraft to the asteroid's surface, and developed a new sampling technique called "Bullseye TAG," which uses images of the asteroid surface to navigate the spacecraft all the way to the actual surface with high accuracy. The mission's performance so far has demonstrated the new standards are within its capabilities.

"Although OSIRIS-REx was designed to collect a sample from an asteroid with a beach-like area, the extraordinary in-flight performance to date demonstrates that we will be able to meet the challenge that the rugged surface of Bennu presents," said Rich Burns, OSIRIS-REx project manager at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "That extraordinary performance encompasses not only the spacecraft and instruments, but also the team who continues to meet every challenge that Bennu throws at us."

The four candidate sample sites on Bennu are designated Nightingale, Kingfisher, Osprey, and Sandpiper—all birds native to Egypt. The naming theme complements the mission's two other naming conventions—Egyptian deities (the asteroid and spacecraft) and mythological birds (surface features on Bennu).

The four sites are diverse in both geographic location and geological features. While the amount of sampleable material in each site has yet to be determined, all four sites have been evaluated thoroughly to ensure the spacecraft's safety as it descends to, touches and collects a sample from the asteroid's surface.

Nightingale is the northern-most site, situated at 56 degrees north latitude on Bennu. There are multiple possible sampling regions in this site, which is set in a small crater encompassed by a larger crater 459 feet (140 m) in diameter. The site contains mostly fine-grain, dark material and has the lowest albedo, or reflection, and surface temperature of the four sites.

Kingfisher is located in a small crater near Bennu's equator at 11 degrees north latitude. The crater has a diameter of 26 feet (8 m) and is surrounded by boulders, although the site itself is free of large rocks. Among the four sites, Kingfisher has the strongest spectral signature for hydrated minerals.

Osprey is set in a small crater, 66 feet (20 m) in diameter, which is also located in Bennu's equatorial region at 11 degrees north latitude. There are several possible sampling regions within the site. The diversity of rock types in the surrounding area suggests that the regolith within Osprey may also be diverse. Osprey has the strongest spectral signature of carbon-rich material among the four sites.

Sandpiper is located in Bennu's southern hemisphere, at 47 degrees south latitude. The site is in a relatively flat area on the wall of a large crater 207 ft (63 m) in diameter. Hydrated minerals are also present, which indicates that Sandpiper may contain unmodified water-rich material.

This fall, OSIRIS-REx will begin detailed analyses of the four candidate sites during the mission's reconnaissance phase. During the first stage of this phase, the spacecraft will execute high passes over each of the four sites from a distance of 0.8 miles (1.29 km) to confirm they are safe and contain sampleable material. Closeup imaging also will map the features and landmarks required for the spacecraft's autonomous navigation to the asteroid's surface. The team will use the data from these passes to select the final primary and backup sample collection sites in December.

The second and third stages of reconnaissance will begin in early 2020 when the spacecraft will perform passes over the final two sites at lower altitudes and take even higher resolution observations of the surface to identify features, such as groupings of rocks that will be used to navigate to the surface for sample collection. OSIRIS-REx sample collection is scheduled for the latter half of 2020, and the [spacecraft](#) will return the asteroid samples to Earth on Sept. 24, 2023.

More information: Explore the final four candidate sites in detail: www.asteroidmission.org/candidate-sample-sites

Provided by NASA's Goddard Space Flight Center

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