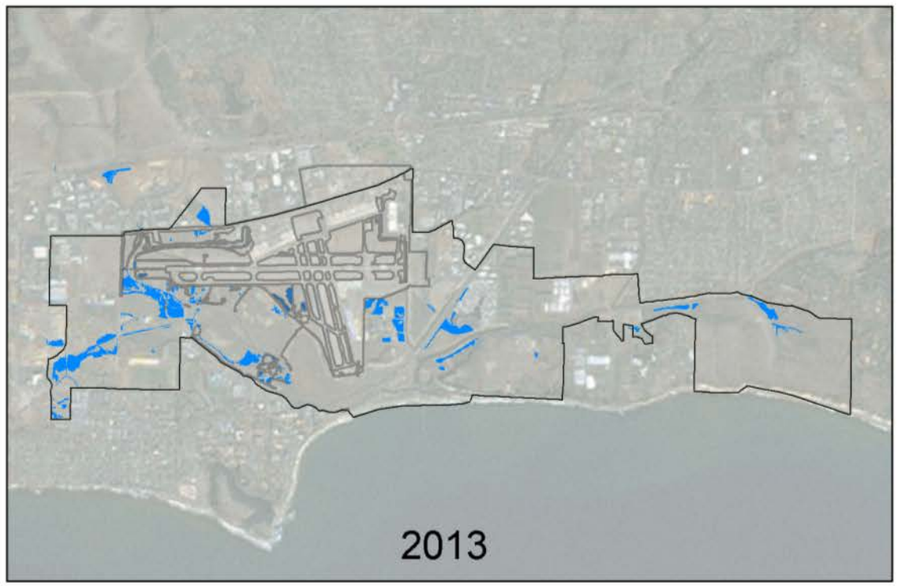
Appendix E – Habitat Vulnerability Summary Sheets

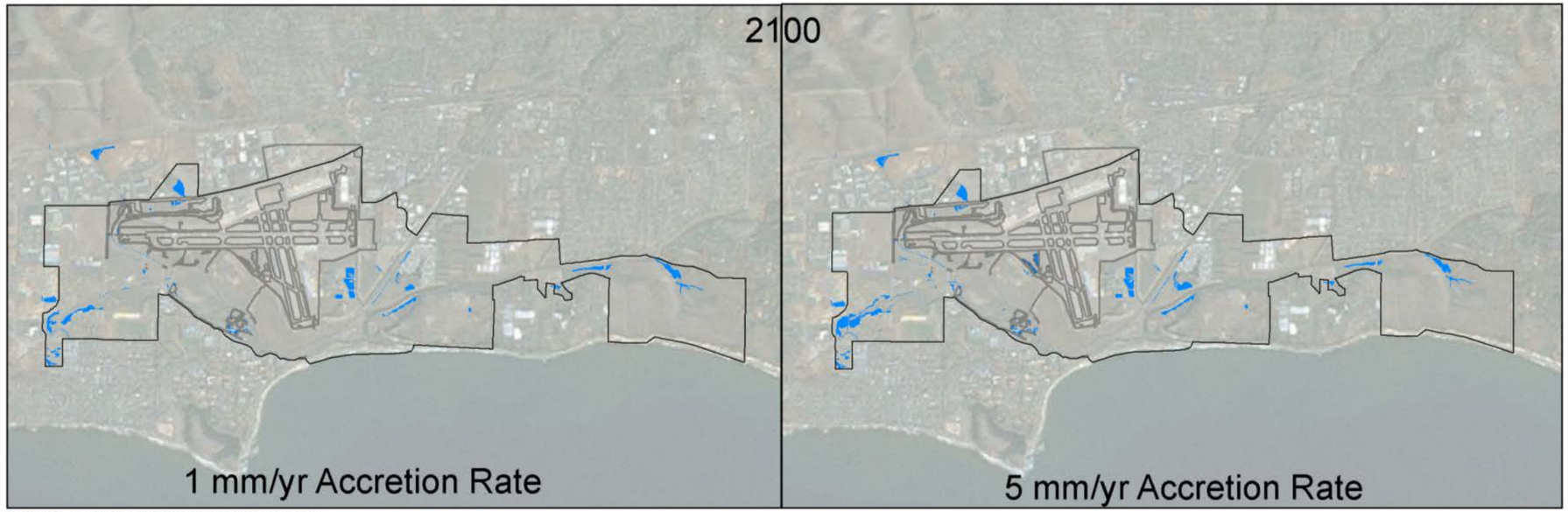
Table of Contents

Table SH-1. Freshwater Marsh / Willow Woodland Habitat Hazard Summary

Function	**Freshwater Marsh/Willow Woodland**
Location	Periodically inundated freshwater marsh habitats occur around the perimeter of Goleta Slough. Common species associated with these habitats include willow, bulrush, cattails and associated songbirds as well as herons, egrets and ducks.
Types of Hazard	Conversion of freshwater marsh habitats to salt marsh.
Exposure to Hazard	Existing freshwater marsh habitats primarily occur around the perimeter of Goleta Slough, particularly within managed pond areas to the south east of the airport as well as along the creek channels. Model results indicate substantial conversion of freshwater marsh habitats to salt marsh habitat with rising sea levels.
Sensitivity to Hazard	Increased sea levels would cause tidal expansion of sea water into areas currently influenced by freshwater. Freshwater plant species would be replaced by salt tolerant plant species. Animal and bird communities would shift in response to changing plant communities.
Vulnerability	• Conversion of habitat types from freshwater to saltwater wetland leads to loss of characteristic plants species. • Loss of freshwater plant species will lead to decline in population of animals dependent on those species.
Risk of Changes	Risk of loss of freshwater marsh habitat is directly linked to increasing sea levels and slough water levels. Low elevation freshwater wetlands in basins and along riparian corridors will be converted to saltwater wetlands due to increased elevation of saline tidal influence.

Figure SH-1. Freshwater Marsh 2100 SLAMM Results Without Tide Gate





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SOURCE: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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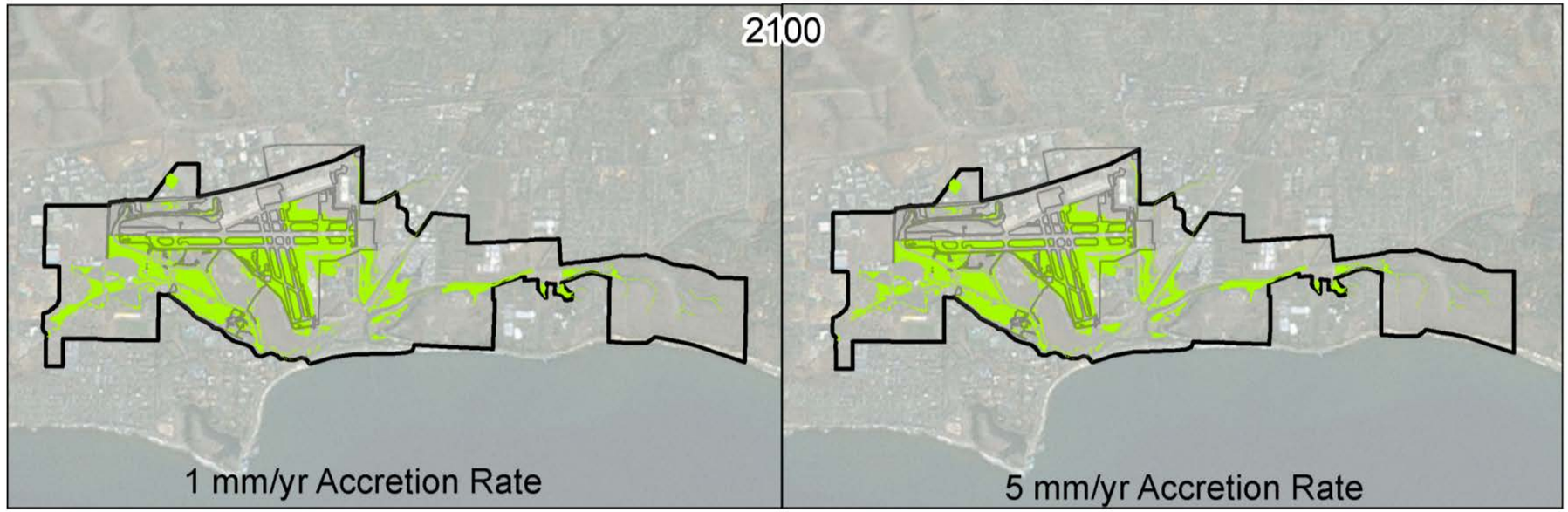
Table SH-2. High Salt Marsh and Transitional Habitat Hazard Summary

Function	**High Salt Marsh and Transition Habitat**
Location	High tidal salt marsh and Transition Habitat is habitat with saline soils that is inundated less than 10% of the time. Under historic lagoon mouth management conditions at Goleta Slough, this habitat generally occurred at elevations ranging from 5.5 to 7.0 ft NAVD.
Types of Hazard	Conversion of existing habitat due to more frequent tidal and fluvial inundation. With modeled increases in sea level and water levels within Goleta Slough, tidal and transition habitats would migrate upslope, replacing existing uplands habitats, while being replaced by salt marsh.
Exposure to Hazard	Habitat evolution modeling for the Goleta Slough ecosystem predicts the conversion of existing upland (dry land) habitats into new transitional tidal habitat. More limited conversion of existing high marsh habitat to salt marsh is also predicted: • Most of the current tidal habitats within Goleta Slough are found in the basins south of airport runways. Transitional habitats frequented by Coulter's Goldfields are located immediately upslope of tidal habitats. • Existing transitional habitat areas are tidally connected to the slough channels and may be impacted by increases in slough water levels. • Regions with salty soils, found in around areas of former tidal exchange including some non-tidal wetlands at the Airport, DFW, and Storke wetlands, influence the distribution of plant species and may be indicators of historical habitat conditions. Under some of the modeled SLR scenarios, some of these areas will be hydrologically connected to tidal exchange in the future.
Sensitivity to Hazard	• Increased sea level and inundation times within Goleta Slough would lead to the conversion of existing transitional and high marsh habitat to tidal wetlands. • Transitional habitat may migrate upslope and across tidal barriers such as berms and levees, displacing existing upland habitat, however the availability of convertible upland habitats is limited by existing infrastructure.
Vulnerability	Conversion of habitat types may lead to the loss of characteristic and rare plant species associated with transitional and high marsh habitats, and loss of animals dependent on those plant species.
Risk of Changes	Risks associated with the conversion of habitats and associated losses are linked to rising water levels, increased inundation times and soil salinity. A more rapid increase in slough water levels increases the risk of habitat loss. Habitat evolution modeling predicts the potential expansion of Transitional and High Marsh habitat extents under future SLR conditions. The expansion of this habitat area may be limited by the management of existing uplands areas, including open space areas within the Airport and near the Storke Wetlands.

Table SH-3. Coulter's Goldfields Habitat Hazard Summary

Function	**Coulter's Goldfields** A rare annual plant (California Native Plant Society 1b.1) currently found in tidal high marsh and on salty soils in historically tidal areas of Goleta Slough.
Location	High Tidal Salt Marsh & Transition Habitats
Types of Hazard	Conversion of existing habitat due to more frequent tidal and fluvial inundation.
Exposure to Hazard	Habitat evolution modeling for the Goleta Slough ecosystem predicts the conversion of upland (dry land) habitat into transitional tidal habitat and the upslope migration of tidal high marsh habitat: • Most of the current tidal habitats within Goleta Slough are found in the basins south of airport runways. Transitional habitats frequented by Coulter's Goldfields are located in and immediately upslope of high salt marsh habitats. Currently the distribution is limited throughout Goleta Slough. • Existing transitional habitat areas are tidally connected to the slough channels and may be impacted by increases in slough water levels. • Regions with salty soils, found in around areas of former tidal exchange including some non-tidal wetlands at the Airport, DFW, and Storke wetlands, influence the distribution of plant species and may be indicators of historical habitat conditions. Under some of the modeled SLR scenarios, some of these areas will be hydrologically connected to tidal exchange in the future.
Sensitivity to Hazard	• A decrease in transitional/high marsh habitat area is expected to result in a reduction in the population of Coulter's Goldfields present at Goleta Slough. • Rapid migration of habitats (even with no net loss in habitat area) may lead to decline in species population due to limited colonization rate.
Vulnerability	• Increases in frequency of inundation Slough water levels decreases survivability of existing plants. • Rapid changes in soil salinity and inundation frequency may limit ability for species to migrate upslope with SLR. • Reduction in area of habitat may lead to significant decline in local Coulter's Goldfields population
Risk of Changes	Risk increases with greater habitat loss and more rapid upland migration of habitats. Habitat loss and conversion is linked to rising seas levels. A more rapid increase in slough water levels increases the risk of habitat loss. Model results indicate substantial movement in the boundaries between high marsh, transition and upland habitats in the absence of intervention measures.
Potential Adaptation Measures	• Control hydrology • Inlet management • Sediment management • Regrade topography • Revegetation • Easement on adjacent upland properties

Table SH-2. High Salt Marsh and Transitional Habitat Hazard Summary



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SOURCE: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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Table SH-4. Salt Marsh Habitat Hazard Summary

Function	**Salt Marsh**
Location	Tidal salt marsh is a wetland habitat that is periodically inundated by saline water on rising tides. Tidal salt marsh habitats are characterized by a collection of plant species, such as pickleweed *(Salicornia virginica),* which are adapted to thrive in a frequently inundated, high salinity environment. Salt marsh species generally occur in areas that are tidally inundated 5% to 45% of the time. Under historic lagoon mouth management conditions at Goleta Slough, this habitat generally occurred at elevations ranging from 3.5 ft to 5.5 ft NAVD[1].
Types of Hazard	Conversion of existing habitat due to more frequent tidal and fluvial inundation. With modeled increases in sea level and water levels within Goleta Slough, salt marsh habitat would migrate upslope, replacing existing high marsh and transitional habitats, while being replaced by mudflats.
Exposure to Hazard	Habitat Evolution Modeling for the Goleta Slough ecosystem predicts the extensive conversion of salt marsh habitat into mudflat and the limited upslope migration of tidal high marsh habitat: • Large areas of Salt Marsh are found within the basins south of airport runways. • Limited pockets of salt marsh occur in areas adjacent to the Atascadero and San Jose Creek channels.
Sensitivity to Hazard	• Increased sea level and inundation times across within Goleta Slough would stress tidal marsh species such as pickleweed, eventually resulting in the conversion of existing salt marsh to mudflat and vegetated intertidal habitats. The conversion of salt marsh to mudflat due to rising sea levels may be slowed or in some cases prevented by accretive processes related to sediment accumulation. • Loss of bio-geochemical cycling functions associated with vegetated marsh (carbon sequestration, nutrient uptake) may compromise lagoon water quality and potentially impact other habitats within the lagoon system. • Salt marsh habitats may migrate upslope, replacing existing High Marsh habitats; however the local topography within Goleta Slough is such that there are few areas where this upslope migration is viable, the most notable are pond areas near Los Carneros and Mesa Rd.
Vulnerability	• Conversion of habitat types may lead to the loss of intertidal pickleweed habitats and loss of animals dependent on those plant species. • The loss of salt marsh habitat would disrupt bio-geochemical cycling associated with vegetated marsh, including carbon sequestration and nutrient uptake.
Risk of Changes	Risks associated with the conversion of salt marsh habitats and associated losses are linked directly to rising water levels within the slough and increased inundation frequencies. Habitat evolution modeling predicts a significant loss of salt marsh habitat under future sea level rise conditions. The extent of habitat loss varies and is based on the availability of sediment within the water column. An increased sediment supply may reduce the risk of salt marsh habitat loss.

Table SH-5. Belding's Savannah Sparrow Habitat Hazard Summary

Function	**Belding's Savannah Sparrow** A rare songbird native to salt marshes along the southern California and Baja California coasts. Belding's Savannah Sparrow (BSS) are year round inhabitants of coastal salt marshes that nest primarily in intertidal pickleweed habitat (vegetated salt marsh).
Location	Mid and High salt marsh
Types of Hazard	The loss of salt marsh habitat may eliminate a substantial proportion of the current high density nesting habitat for state-endangered BSS in Goleta Slough.
Exposure to Hazard	Habitat Evolution Modeling for the Goleta Slough ecosystem predicts the conversion of a large fraction of the existing salt marsh to mudflats. The modeled losses of vegetated tidal salt marsh and corresponding increases in mudflat areas in the main intertidal basins of Goleta Slough would have substantial impacts on the current breeding habitat of Belding's Savannah Sparrow. • Primarily in basins south of the airport runways
Sensitivity to Hazard	• Increased sea level and inundation times would cause upslope migration of intertidal salt marsh habitats leaving large areas of unvegetated mudflats which would be unsuitable for nesting habitat for BSS. • Remaining intertidal marsh, and areas of new intertidal marsh would be in closer proximity to upland habitats, leading to increased vulnerability from competitor and predator species.
Vulnerability	• The loss of intertidal pickleweed habitat, used for nesting, could have a profound negative impact on the local population, especially if intertidal pickleweed habitats do not have room to move upslope.
Risk of Changes	The risk of loss to key BSS nesting areas is linked directly to the risk of loss of vegetated salt marsh habitats. The risk increases with more rapid increases in water levels within the slough, while an increased sediment supply may reduce the rate of salt marsh habitat conversion to mudflat.

Figure SH-3. Salt Marsh Habitat 2100 SLAMM Results Without Tide Gate

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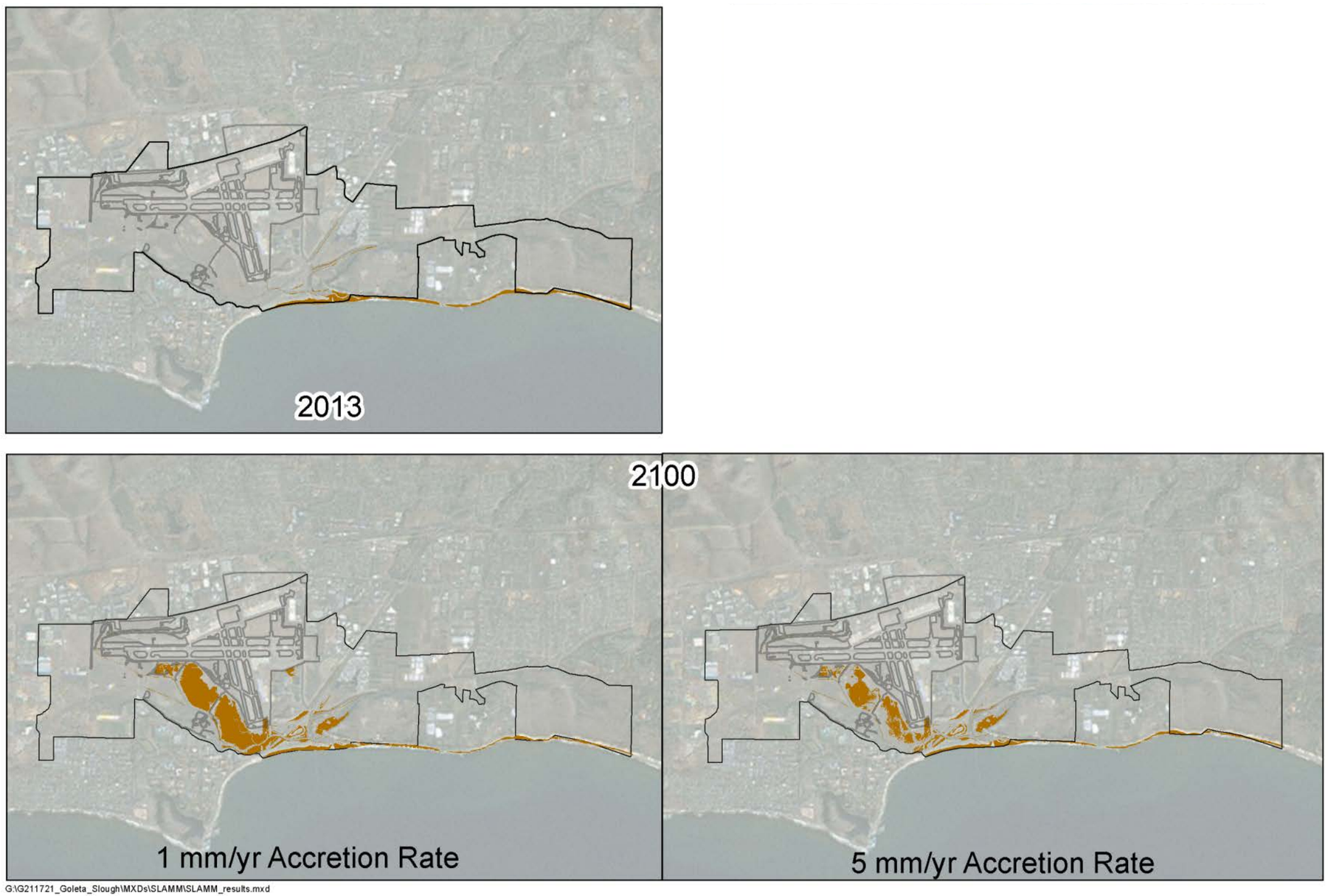
Table SH-6. Tidal Mudflats Habitat Hazard Summary

Function	**Tidal Mudflats**
Location	Tidal mudflats areas are frequently inundated inter-tidal habitats which are not heavily colonized by wetland vegetation but rather characterized by deposits of silty or clayey sediment. These areas are typically inundated 45% to 100% of the time, corresponding to an elevation band between 0 and 3.5 ft NAVD at Goleta Slough under historic lagoon mouth management to maintain an open inlet[1]. Tidal mudflats are currently distributed along the edges of tidal channels from the inlet at Goleta Beach westward through to the tidal saltmarsh areas south of the airport runways. Unvegetated muddy habitat also occurs in depressions in both tidal and non-tidal areas.
Types of Hazard	Habitat evolution modeling indicates that there will be substantial INCREASES in mudflat habitat under future sea level rise conditions due to the conversion of vegetated salt marsh into mudflat through increased tidal inundation.
Exposure to Hazard	The most substantial changes anticipated in the Goleta Slough ecosystem (by area) under projected sea level rise conditions are the loss of vegetated intertidal marsh and the increase in the extent of unvegetated tidal mudflat. This habitat conversion is most prominent in the basins south of airport runways.
Sensitivity to Hazard	Increased water levels and inundation times is expected to cause upslope migration of both mudflat and vegetated intertidal habitats. Due to the limited extent of available transitional habitats, this upslope migration will result in a net increase in mudflat area while the extents of tidal saltmarsh will be greatly reduced.
Vulnerability	• Change in existing management may increase area of mudflat habitats • Increased extents of unvegetated mudflats will provide increased forage and habitat opportunities for shorebirds. • Loss of characteristic saltmarsh plant species (pickleweed) will adversely affect animals dependent on those species, including rare species associated with those habitats (e.g. Belding's Savannah Sparrow). • Loss of bio-geochemical cycling functions associated with vegetated marsh (carbon sequestration, nutrient uptake) may compromise lagoon water quality.
Risk of Changes	There is potential for the significant expansion of tidal mudflats within Goleta Slough due to sea level rise. Risks associated with the conversion of habitats and associated losses are linked directly to rising sea level and water levels within Goleta Slough.

Table SH-7. Shorebirds Habitat Hazard Summary

Function	**Shorebirds**
Location	Shorebirds feed primarily on tidal mud flats areas that are currently distributed along tidal channels from the inlet at Goleta Beach westward through to the tidal saltmarsh areas south of the airport runways. Unvegetated muddy habitat also occurs in depressions in both tidal and non-tidal areas. Shorebird numbers vary through the year with low numbers in the summer peaks during two migration seasons (Aug-Nov) and Spring (Mar-early May) and intermediate densities during the over-wintering period (Dec-Feb). Typical mudflat feeding species include: Western Sandpipers, dowitchers, Marbled Godwits, Willets, Black-bellied Plovers, Whimbrels, Least Sandpipers, Killdeer, and Greater Yellowlegs.
Types of Hazard	Habitat evolution modeling indicates that there will be substantial increases in mudflat habitat under future sea level rise conditions due to the conversion of vegetated salt marsh into mudflat through increased tidal inundation.
Exposure to Hazard	The most substantial changes anticipated in the Goleta Slough ecosystem (by area) under projected sea level rise conditions are the of loss of vegetated intertidal marsh and the increase in the extent of unvegetated tidal mudflat. This habitat conversion is most prominent in the basins south of airport runways.
Sensitivity to Hazard	Increased water levels and inundation times are expected to cause upslope migration of both mudflat and vegetated intertidal habitats. Due to the limited extent of available transitional habitats, this upslope migration will result in a net increase in mudflat area, while the extents of tidal saltmarsh will be greatly reduced. Shorebirds may experience significant benefits from these changes due to the larger foraging areas.
Vulnerability	• Increased extents of unvegetated mudflats will provide increased forage and habitat opportunities for shorebirds. • Increases in macroalgae, epibenthic microalgae, characteristic invertebrates of tidal mud flats • Increased density and diversity of migratory and over-wintering shorebirds can be expected with increased habitat and prey resources.
Risk of Changes	Shorebird populations may benefit from larger forage areas due to the conversion of salt marsh to mudflats under future sea level rise conditions. Risks associated with the conversion of habitats and associated losses are linked directly to rising sea level and water levels within Goleta Slough.

Figure SH-4. Mudflat Habitat 2100 SLAMM Results Without Tide Gate



SOURCE: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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Table SH-8. Tidal Creek and Subtidal Habitat Hazard Summary

Function	**Tidal Creek and Subtidal Habitat**
Location	Tidal creeks & subtidal habitats are deep open water habitats that are hydraulically connected to the lagoon mouth. These areas area continually inundated even during the lowest tides. Creek and subtidal habitats are distributed from the inlet at Goleta Beach through Goleta Slough to the non-tidal creek reaches that enter the estuary from the upper watersheds.
Types of Hazard	• Habitat evolution model results indicate little change in the area of these habitats with sea level rise. The models show a *very* slight increase in subtidal habitat area in Goleta Slough. • The quality of subtidal habitat may decline due to changes in other habitat zones due to potential loss of shade trees associated with upland habitat and reduction in water quality benefits associated with decline in salt marsh health.
Exposure to Hazard	Subtidal open water occurs near the lagoon mouth. In addition, tidal creeks/creeks are significant features of the western, southern & eastern edges of Goleta Slough, e.g. Tecolotito, Los Carneros, San Pedro, San Jose, Atascadero
Sensitivity to Hazard	Increased lagoon water levels might cause expansion and upslope migration of both deepwater & tidal creek habitats. SLAMM habitat modeling indicates little change in subtidal habitat area under projected sea level rise conditions, probably due to: 1. the relatively high elevations of Goleta Slough marsh plain; 2. the steep-sided character of channelized creeks in GS; and 3. the limited ability of the SLAMM habitat model to represent the development of new tidal channels.
Vulnerability	• Potential minor increase in fish habitat, and increase of Southern Steelhead nursery habitat. • Potential benefits to fish passage- higher water levels, reduced barrier thresholds • Potential water temperature benefits with increased depths, possibly offset by loss of channel shading due to increase inundation of upland/transitional habitats. • Potential minor increase in tidewater goby habitat. • Potential impacts to creek/subtidal habitat quality due to changes in nutrient availability related to the conversion of saltmarsh to mudflats
Risk of Changes	There is little risk of loss of creek/subtidal habitat areas due to sea level rise. The primary risks to the creek and subtidal habitats in Goleta Slough are related to potential habitat quality and water quality impacts due to changes in extent of neighboring saltmarsh and transitional riparian habitats.

Table SH-9. Water Birds Habitat Hazard Summary

Function	**Water birds (waterfowl, waders, gulls)**
Location	• Tidal open water areas • Periodically inundated wetland basins • A variety of migratory and local waterfowl populate Goleta Slough
Types of Hazard	Elevated water levels within the slough increase the area of inundation, which has been observed to attract larger populations of water birds. High densities of water birds near the airport lead to an elevated risk of bird air strike hazards.
Proximity to Hazard	Modeling indicates that as sea level rises, larger areas of Goleta Slough will be inundated by tides for longer periods. • Topographic basins may be filled by high tides and retain salt or brackish water for more days of the year. • The presence of large areas of open water may increase the use of the area by guilds of birds associated with this habitat type. • Wetland areas with tidal connections to the ocean occur throughout Goleta Slough.
Anticipated Changes	The increased water bird populations may greatly increase the Bird Airstrike Hazard (BASH).
Severity of Changes	Recent data from the airport has shown that the densities of waterfowl increased dramatically with increased availability of open water (eg. due to lagoon inlet closure) during migration season. Increased densities can elevate the Bird Airstrike Hazards, which can pose critical aviation risks • Increased frequency of hazing actions leading to higher operations costs. • Potential disruption to aviation service. • Potential for damaging bird airstrike.
Risk of Changes	Increased inundation times due to tidal action and increases in slough water levels are linked directly to rising seas levels and beach sand levels. Water levels within the slough, and consequently water bird populations, are also strongly affected by the management of the lagoon mouth inlet.

Table SH-10. Southern Steelhead and Tidewater Goby Habitat Hazard Summary

Function	**Southern Steelhead and Tidewater Goby** These endangered fish species have been observed in the open water/subtidal areas of Goleta Slough. Steelhead have historically migrated through tidal lagoons along the California coast to reach spawning habitats in upstream reaches of coastal creeks, however changes in land use and channel structure (armoring, culverts, fish passage barriers) have greatly reduced the availability of spawning habitat. Tidewater Goby are year round residents of Goleta Slough
Location	These endangered fish species have been observed in the tidal creeks and subtidal habitats that are distributed from the inlet at Goleta Beach through Goleta Slough to the non-tidal creek reaches that enter the estuary from their upper watersheds.
Types of Hazard	Model results indicate that there will be little change in the area of these habitats with sea level rise given the largely constrained channels. These species may be adversely impacted by changes in lagoon water quality.
Exposure to Hazard	Subtidal open water occurs near the lagoon mouth. In addition, tidal creeks are significant features of the western, southern & eastern edges of Goleta Slough: Tecolotito, Los Carneros, San Pedro, San Jose, Atascadero Creeks.
Sensitivity to Hazard	Increased lagoon water levels might cause the expansion and upslope migration of both deepwater & tidal creek habitats. SLAMM habitat modeling indicates very little change in subtidal habitat area under projected sea level rise conditions, probably due to the relatively high elevations of Goleta Slough marsh plain; the steep-sided character of channelized creeks in GS; and the limited ability of the SLAMM habitat model to represent the geomorphic development of new tidal channels.
Vulnerability	• Potential minor increase in fish habitat, including a potential increase of Southern Steelhead nursery habitat. • Potential benefits to fish passage- higher water levels within the lagoon may reduce effect of some fish passage barriers between lagoon and lower creeks. • Potential water temperature benefits with increased depths. • Potential minor increase in tidewater goby habitat. • Potential decrease in water quality with conversion of saltmarsh to mud flat habitat area and associated diminished capacity for nutrient uptake. • Potential reduction in channel shading and vegetation structure near subtidal habitat due to inundation of transitional riparian habitat. • Freshwater interface will move upstream leading to increased salinities in lower lagoon.
Risk of Damage	There is little risk of loss of creek/subtidal habitat areas due to sea level rise. The primary risks to these species in Goleta Slough, relative to existing conditions, are related to potential habitat quality and water quality impacts due to changes in the extent of neighboring saltmarsh and transitional riparian habitats.

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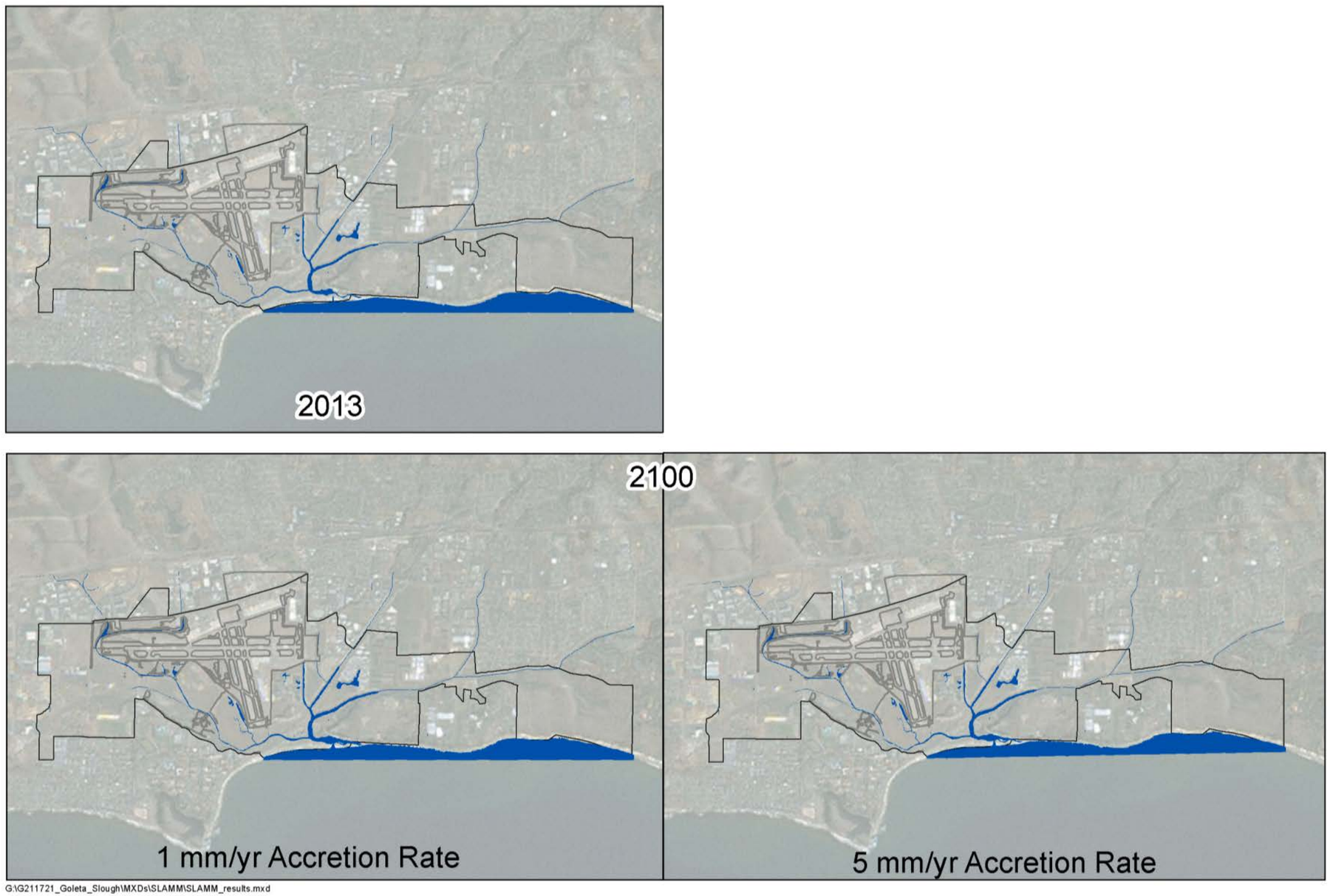
Figure SH-5. Creek Channels and Subtidal Habitat 2100 SLAMM Results Without Tide Gate



SOURCE: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community