La pura vida!

Nosara, Costa Rica

CE292B: Climate Resilient Infrastructure Design

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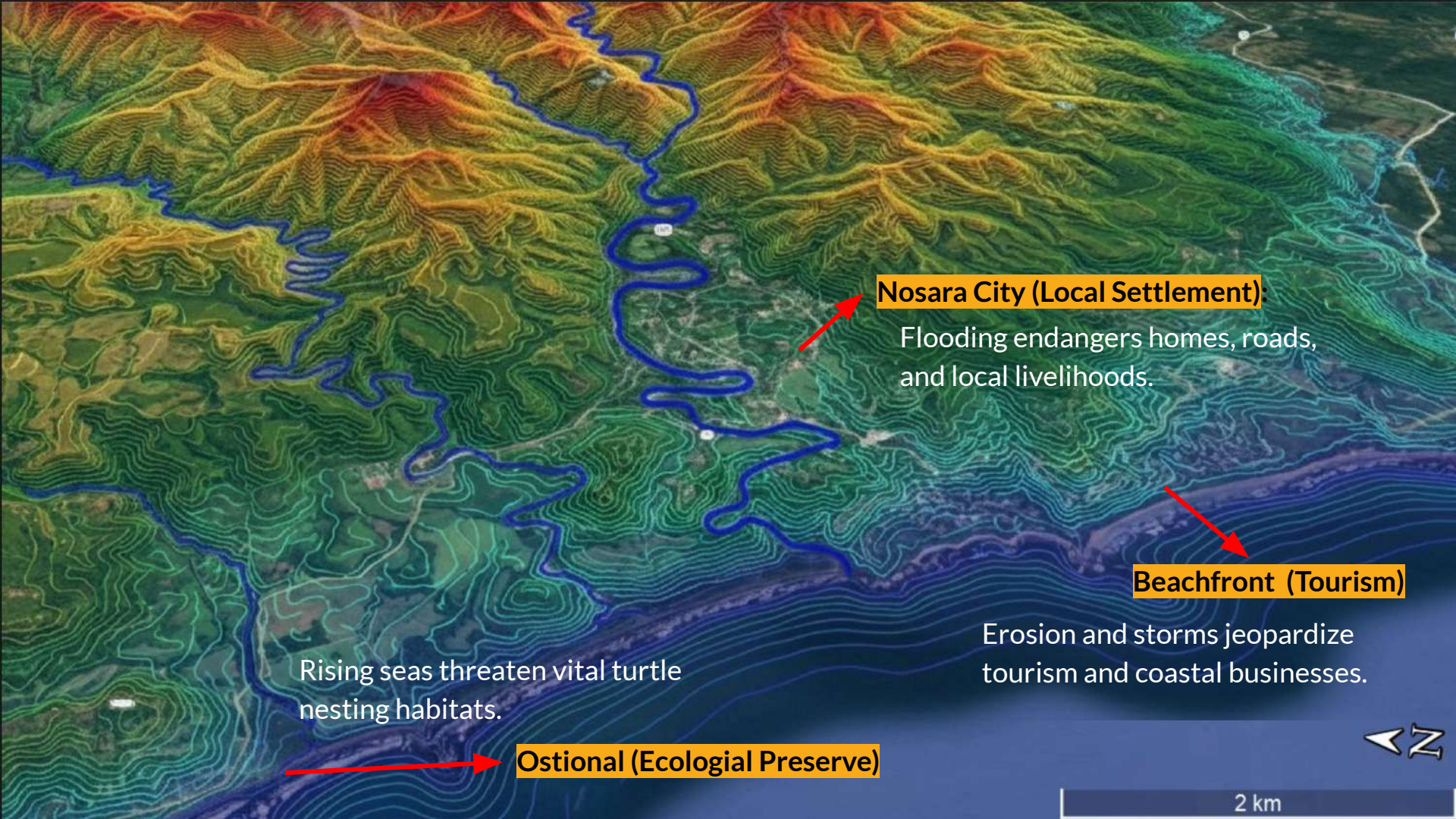
Where is Nosara?

The place to find *La pura vida!*


Nosara City (Local Settlement):
Flooding endangers homes, roads, and local livelihoods.
Beachfront (Tourism)
Erosion and storms jeopardize tourism and coastal businesses.
Rising seas threaten vital turtle nesting habitats.
Ostional (Ecologial Preserve)
N
2 km

Nosara, coastal town where culture and nature coexist

Sea Turtles

Nesting site for **the Olive Ridley sea turtle.**

(Nicoyapeninsula.com, n.d.).

Blue Zone

Earned a **"Blue Zone"** for the longevity of its residents.

(Blue Zones, n.d.)

Oceans & Surfing

Attracts surfers worldwide to its beaches

(Vacations Costa Rica.com, n.d.).

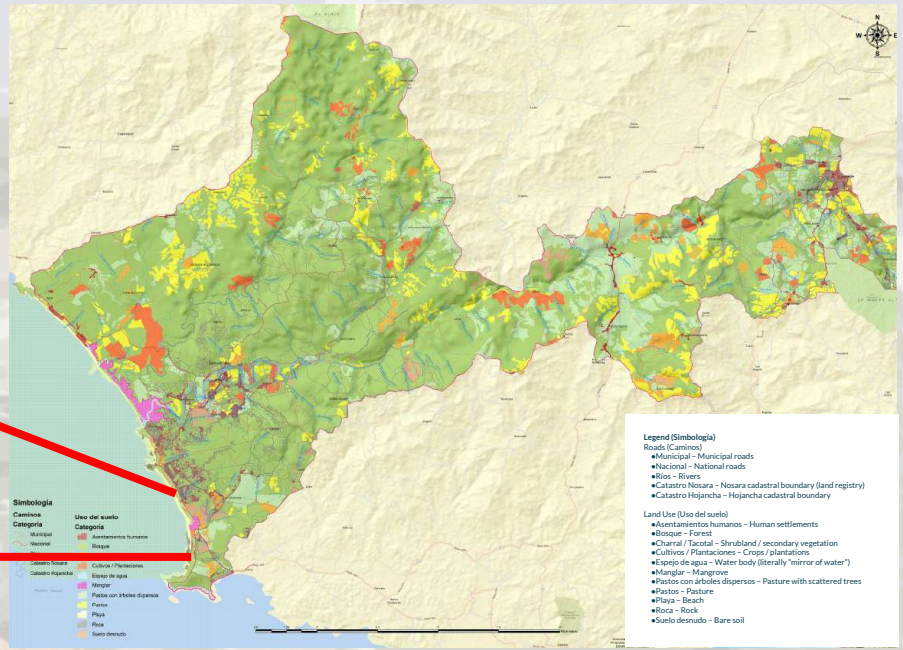
Monkeys & Forests

Home to **diverse wildlife**, including **Howler and Capuchin monkeys**.

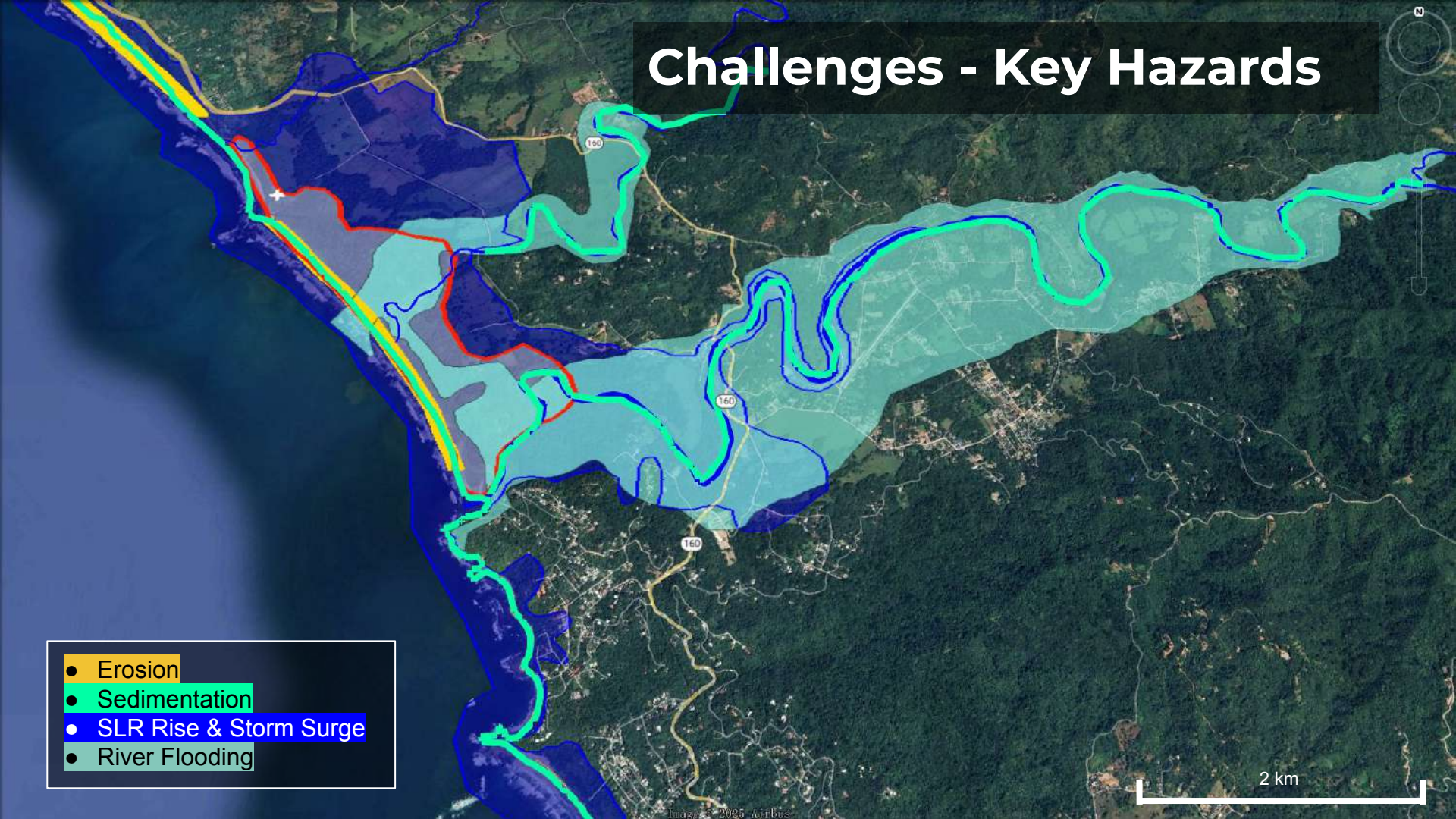
(Nicoya Peninsula, n.d.)

Tourism-driven growth and coastal development.

- Property values have appreciated **8–12% annually over the past decade** (Investing Costa Rica, n.d.).
- Population doubled since 2000

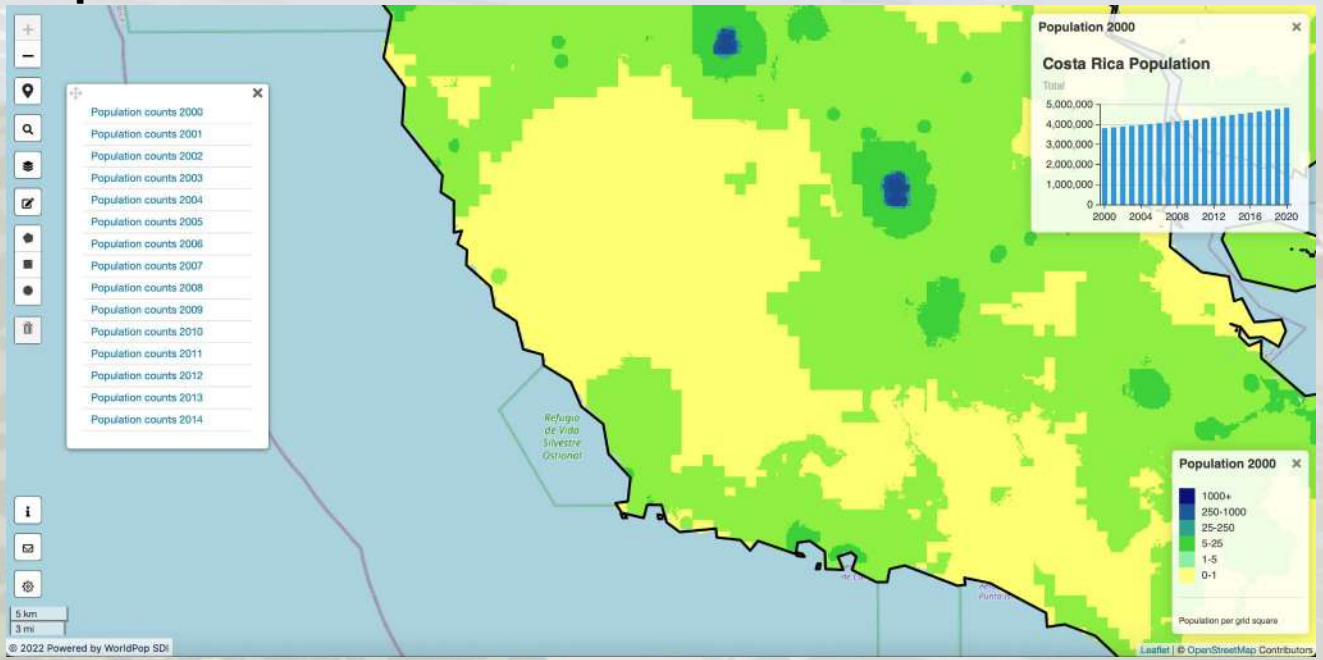


Challenges - Key Hazards



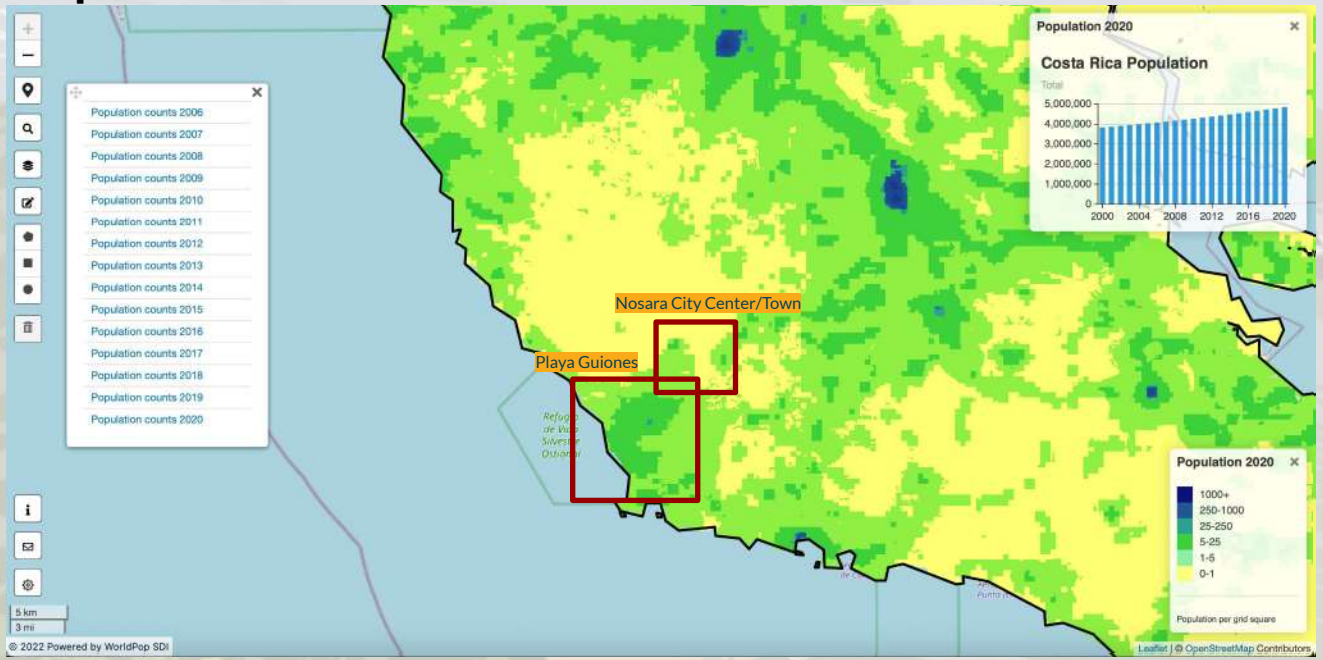
Rapidly growing coastal population driven by tourism and migration.

Population counts 2000

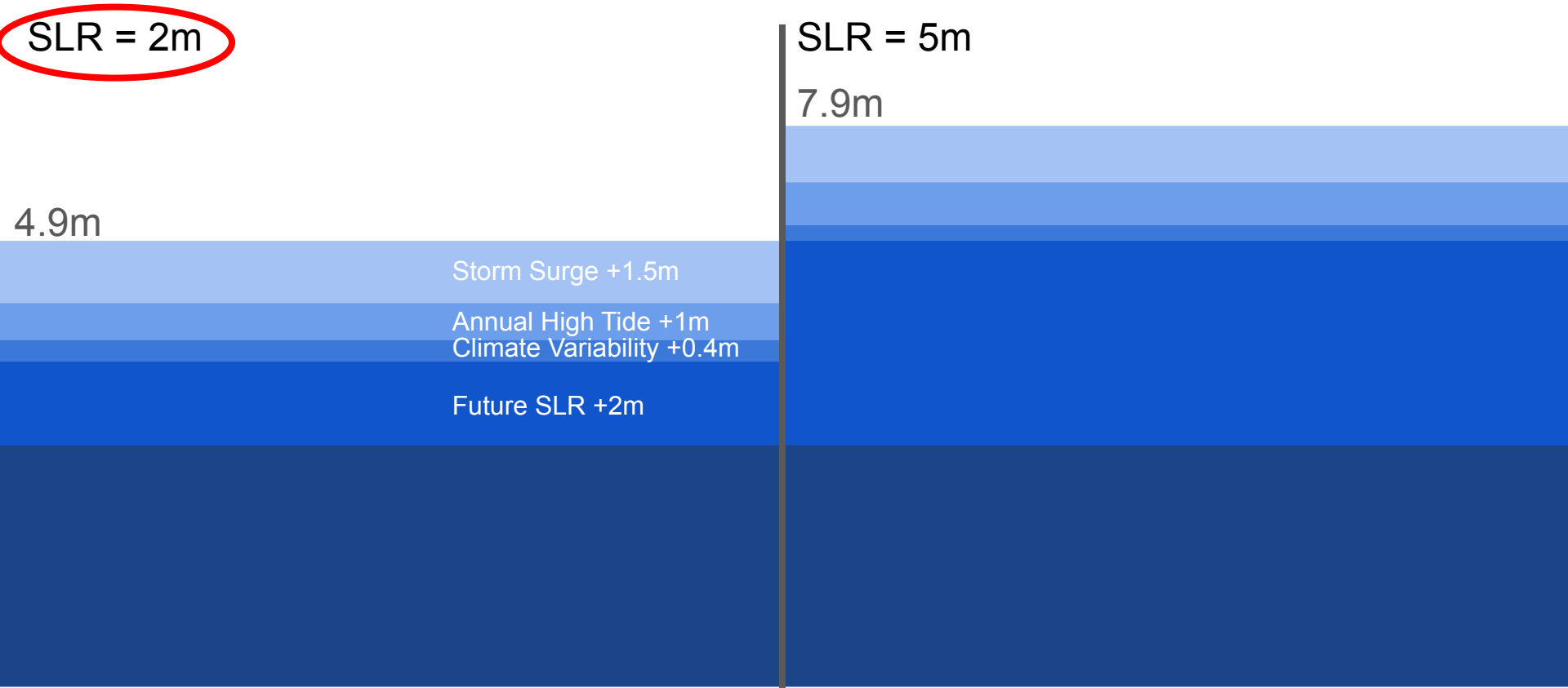


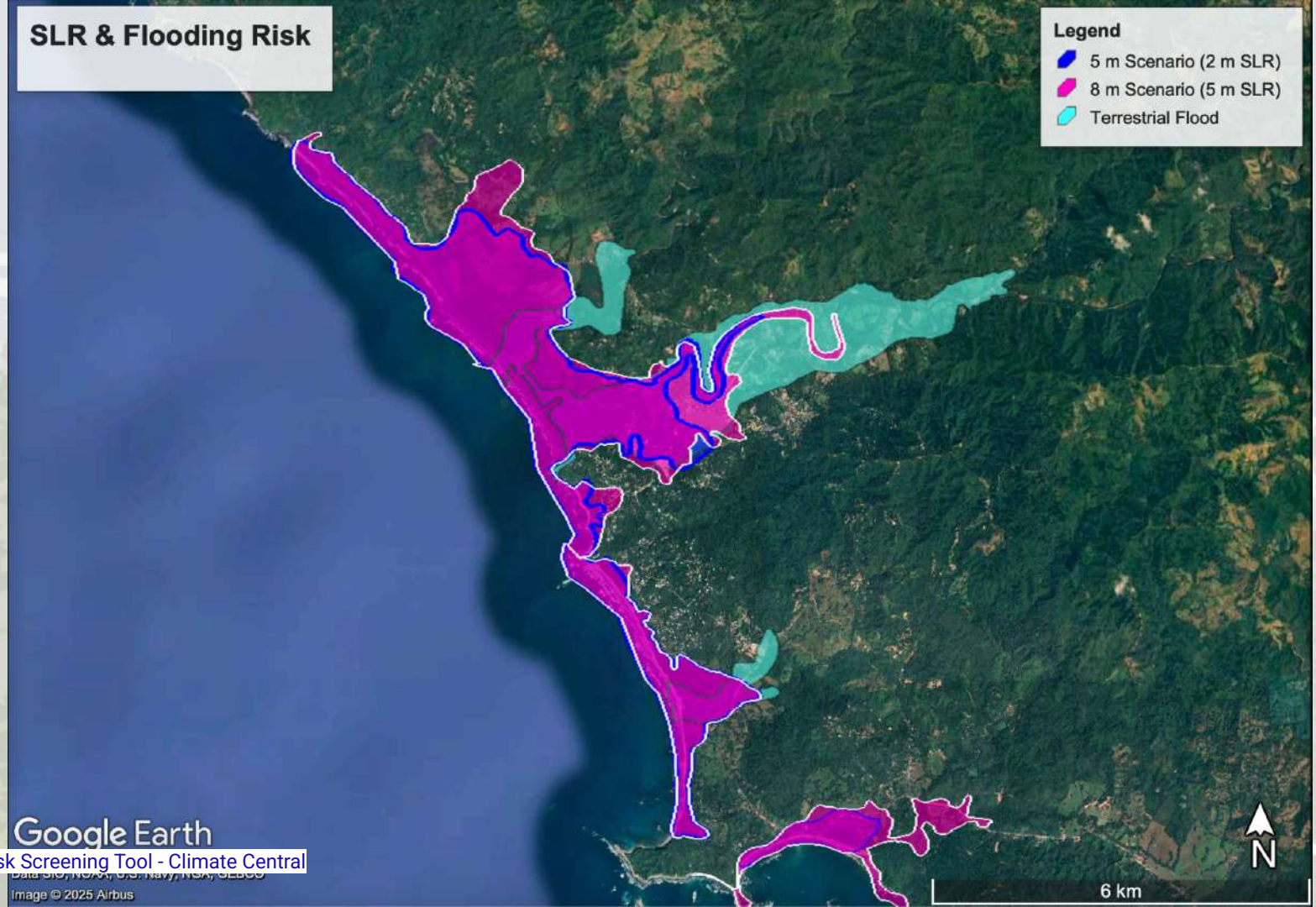
Rapidly growing coastal population driven by tourism and migration.

Population counts 2020



SLR Assumptions (Layer Cake)





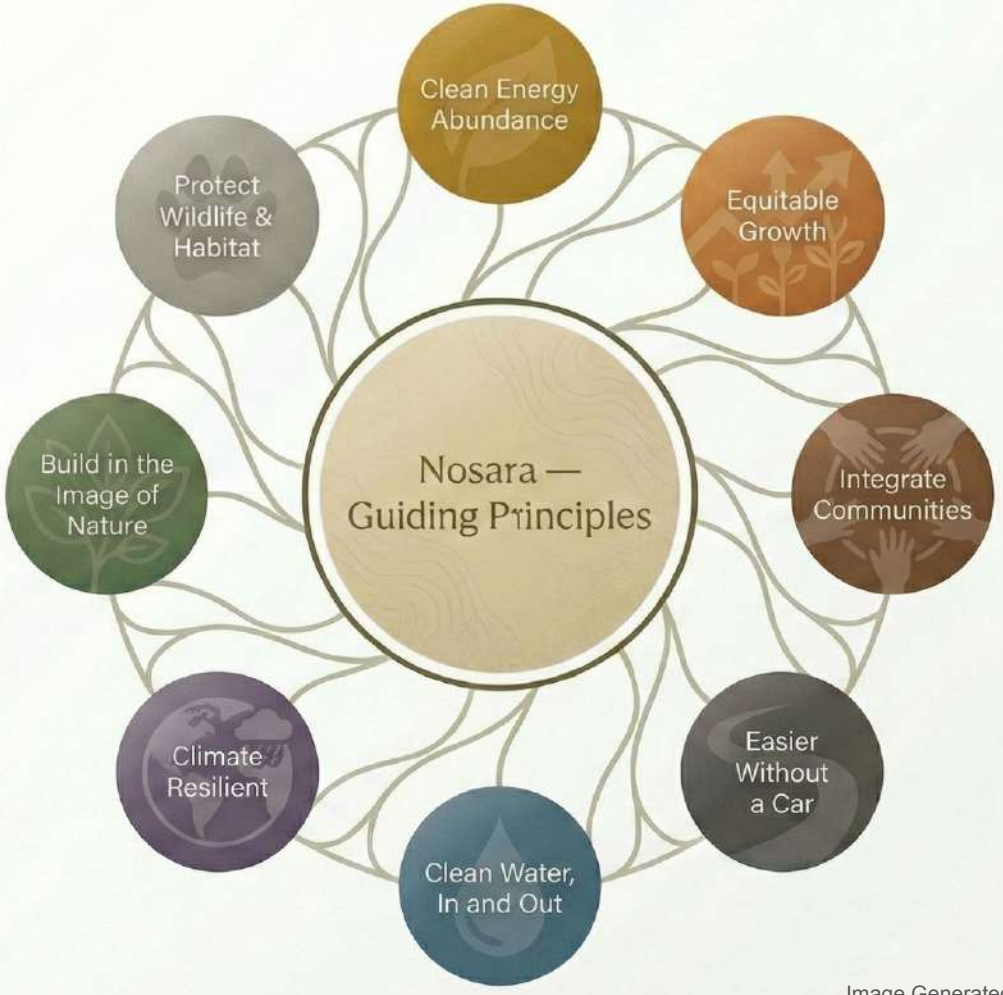
Coastal Risk Screening Tool - Climate Central

Future forecast of climate risks

Category	Driver	Impacts on Nosara
Sea-Level Rise (SLR)	2 - 5 m SLR	Flooding of low-lying inland terrain Beach retreat
Hydrology	Drought Terrestrial flood	Lower groundwater table Inland flood
Urbanization	Higher density Impervious infrastructure	Increased stormwater runoff **Require resilient infrastructure**

What is at risk if no action is taken?

https://ticotimes.net/2018/10/05/live-heavy-rains-lead-to-mass-floods-in-the-pacific



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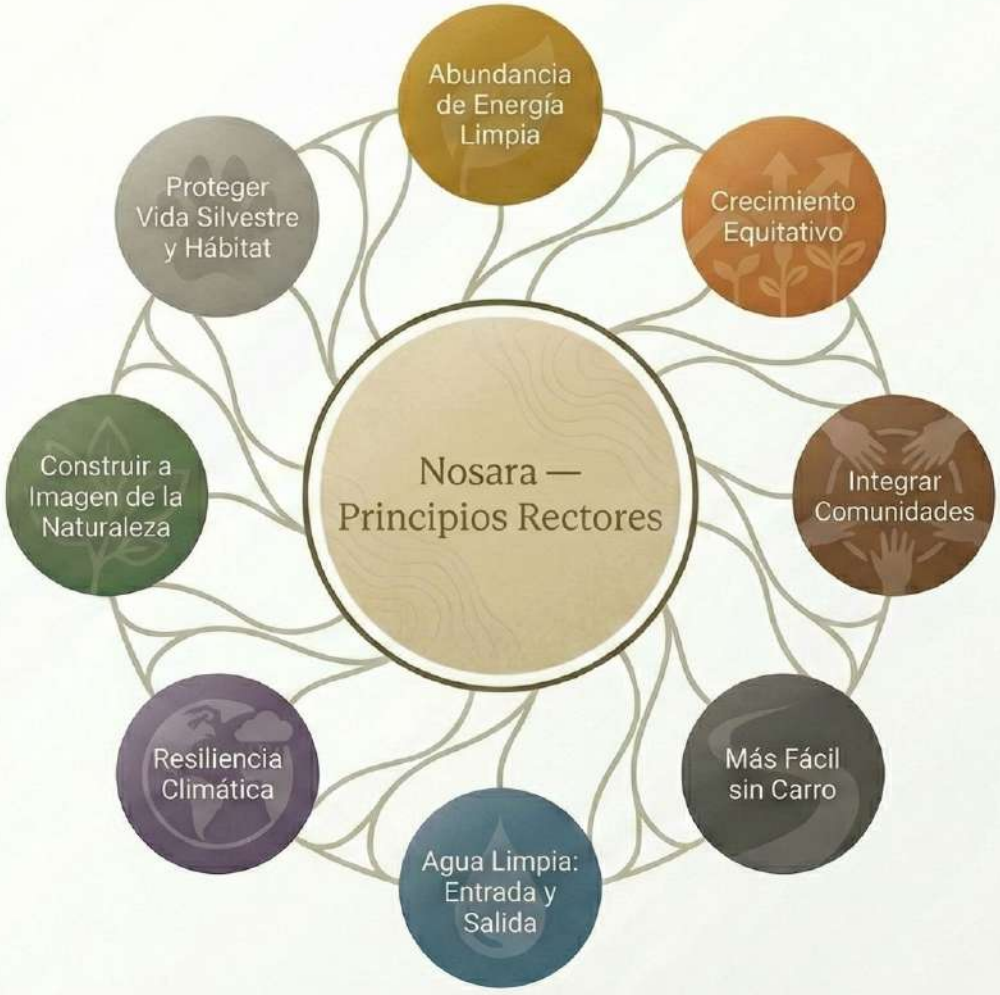

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A Leader in Ecological Preservation and Research

- Expand ecological preserves & protect turtle habitat
- Expand mangroves
- Reforestation throughout watershed
- Riparian buffers

Image Generated with Gemini

Integrated Communities, Equity & Shared Wealth

A Year-Round, Stable Economy

- Diversified Economy
- Local Jobs & Training
- Transportation from Valley to Beach
- Tourism Impact Fees & Real Estate Tax
- Transfer of Development Rights

Image Generated with Gemini

Resilient to Climate Risks

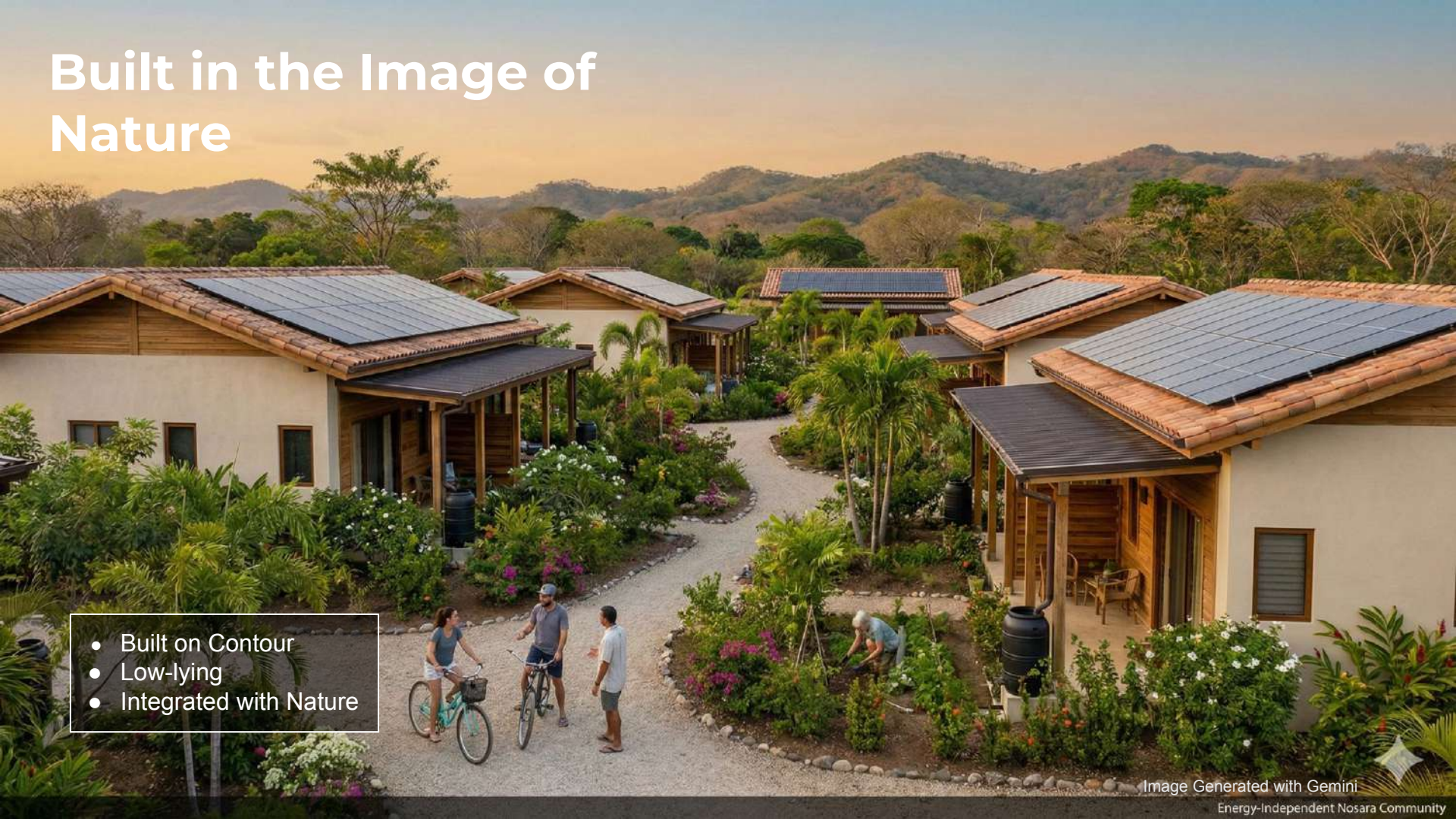
Resilient to Climate Risks

- Green levees
- Watershed reforestation
- Detention ponds
- Riparian buffers
- Groundwater recharge

Image Generated with Gemini


Clean Water In...
Groundwater Recharge
Centralized Wastewater
Biofiltration
Riparian Buffers
Clean Water Out...
Image Generated with Gemini

Built in the Image of Nature



- Built on Contour
- Low-lying
- Integrated with Nature

Image Generated with Gemini

Energy Abundance

- Solar Power
- Battery Storage
- Local Distribution

Image Generated with Gemini

Easier WITHOUT a Car

- Multimodal Transportation
- Improved local infrastructure
- Fees on personal car ownership
- Limited parking

Image Generated with Gemini

Precedents Projects

Design with the water, not against it.

Retention lakes → Floodable parks → Wetland connectivity

ATAL SAROVAR | INDIA

Community Waterfront

Bishan–Ang Mo Kio Park | Singapore

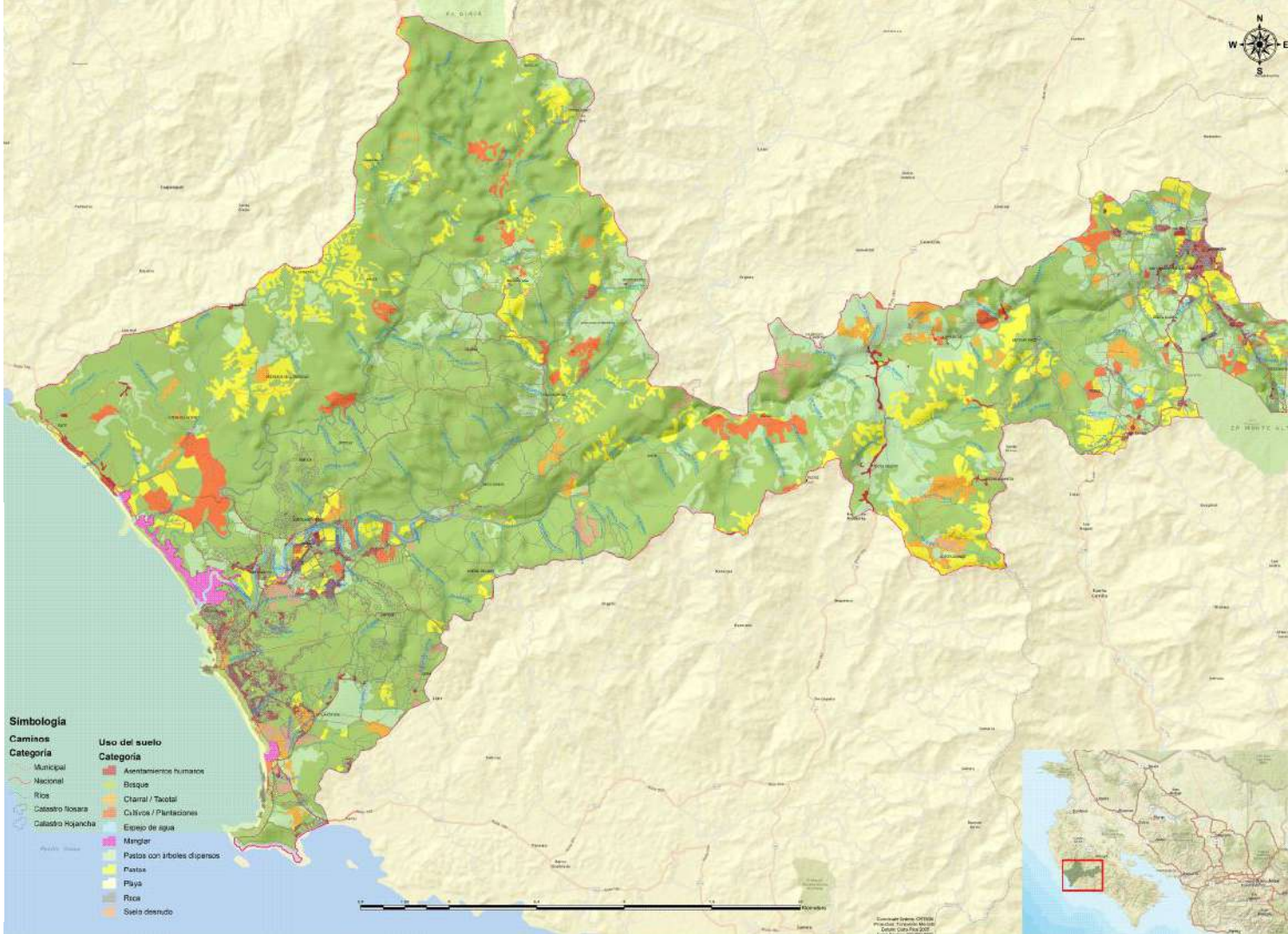
Natural River Channels & Soft Banks

Yanweizhou Park | China

High Bridge & Submersion Adaption

Wetland

Ecological Map



Legend (Simbología)

Roads (Caminos)

- Municipal – Municipal roads
- Nacional – National roads
- Ríos – Rivers
- Catastro Nosara – Nosara cadastral boundary (land registry)
- Catastro Hojancha – Hojancha cadastral boundary

Land Use (Uso del suelo)

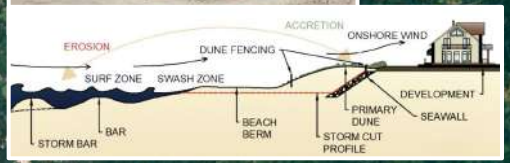
- Asentamientos humanos – Human settlements
- Bosque – Forest
- Charral / Tacotal – Shrubland / secondary vegetation
- Cultivos / Plantaciones – Crops / plantations
- Espejo de agua – Water body (literally "mirror of water")
- Manglar – Mangrove
- Pastos con árboles dispersos – Pasture with scattered trees
- Pastos – Pasture
- Playa – Beach
- Roca – Rock
- Suelo desnudo – Bare soil

Shoreline Adaptation

- Groynes trap sand moving alongshore
- Sediment accumulated, retain nourished beaches.
- Rebuilds beach width, while dunes and plants add natural buffering.

Legend
- Beach Nourishment
- Groyne
- Sand Dunes in Ostional

Sand Dunes & Local Plants



Beach nourishment

Groynes/training walls

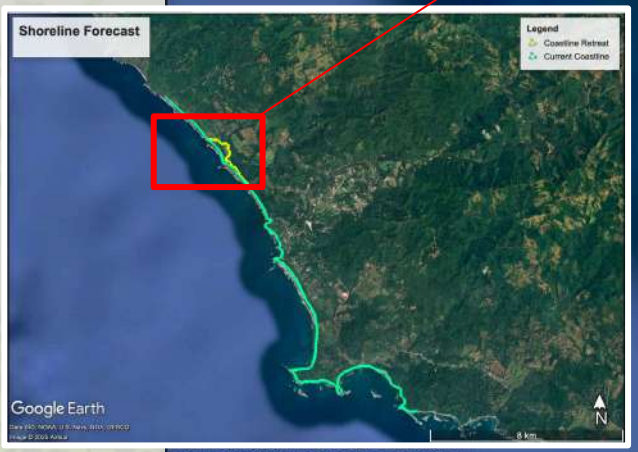
Google Earth

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Image © 2025 Airbus

N

8 km



Shoreline Forecast

Legend
- Coastline Retreat
- Current Coastline

- Retreat is selected because elevation is low and turtles nest here.
- Nourishment is only done partially as extensive nourishment may harm turtle nest substantially
- This zone shifts to retreated coast with mangroves for natural, long-term protection.

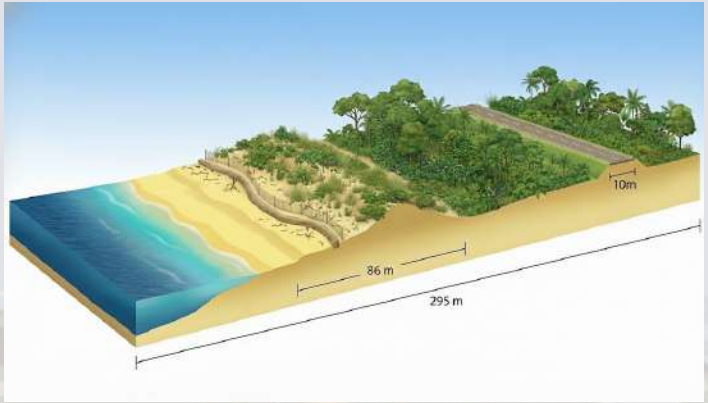
N

2 km

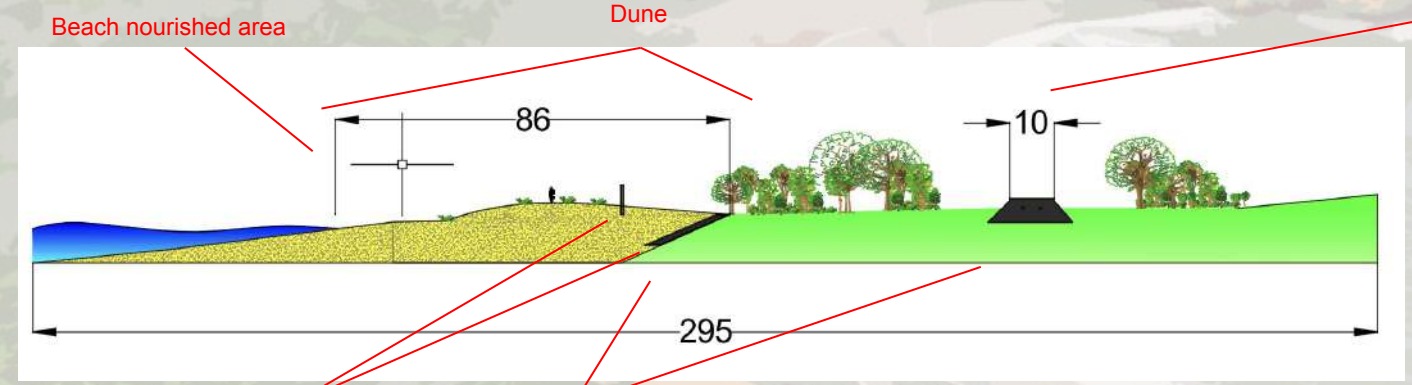
Image © 2025 Airbus

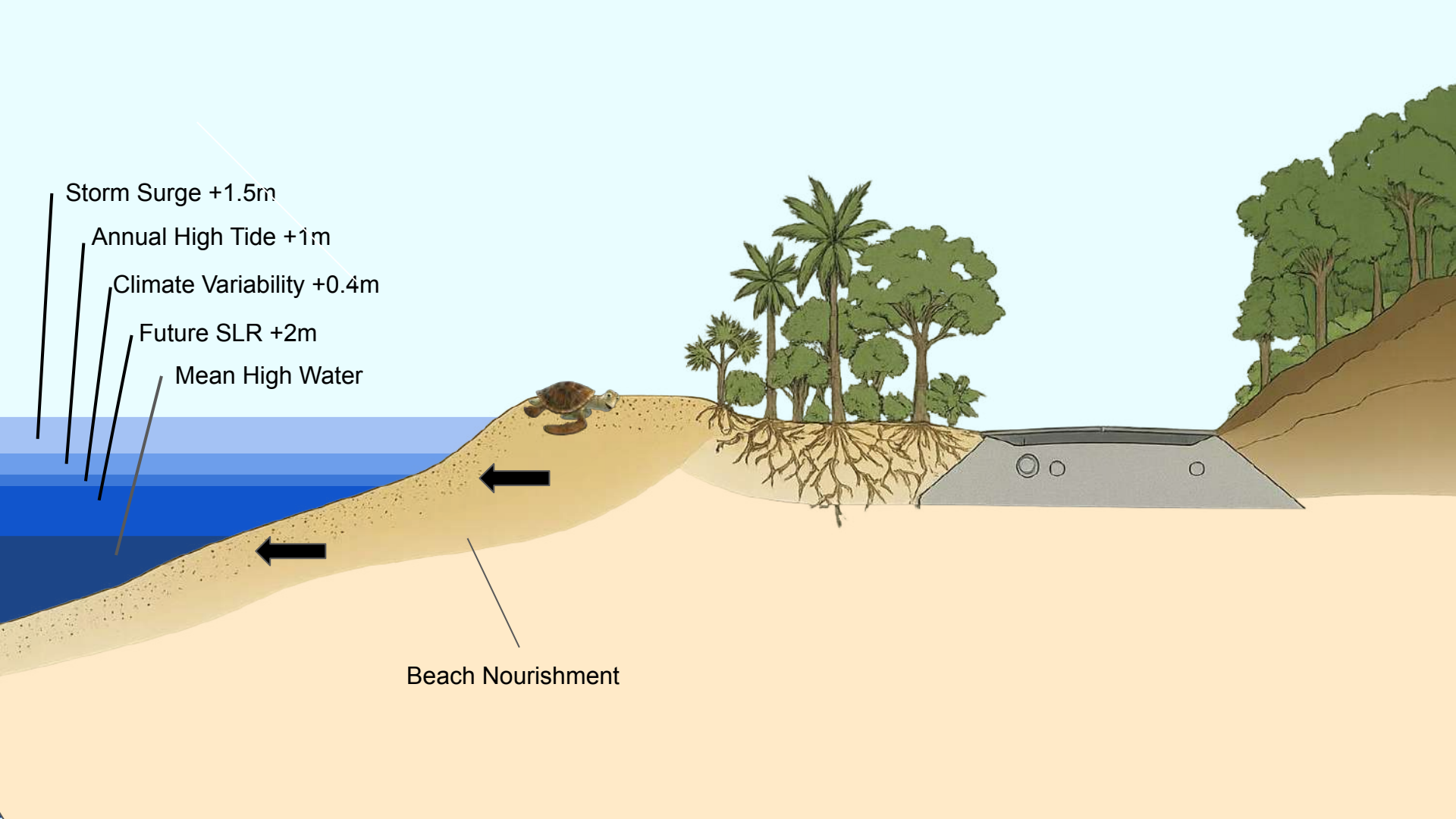
Shoreline Adaptation

Plan



Rough illustration

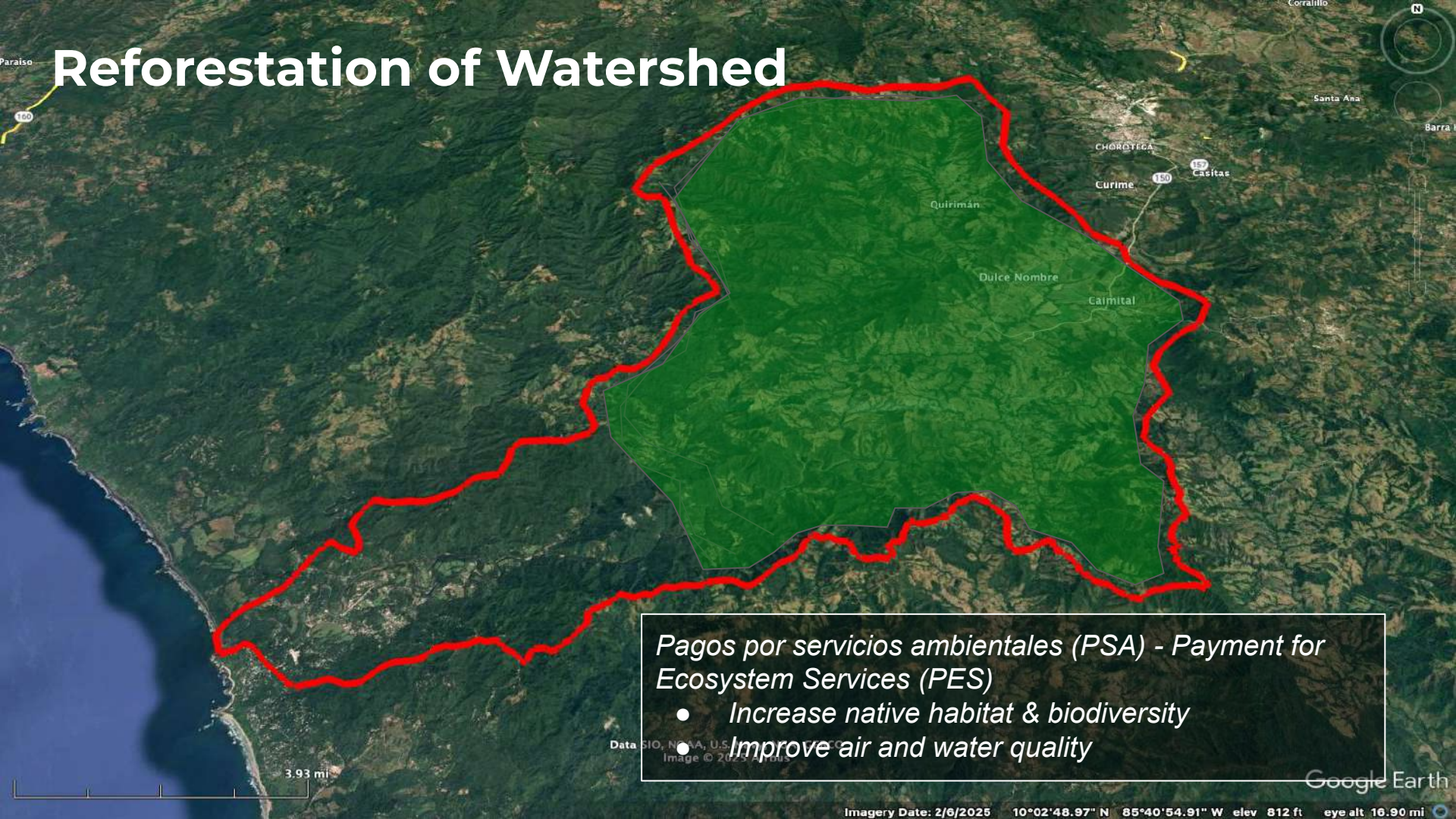



Storm Surge +1.5m
Annual High Tide +1m
Climate Variability +0.4m
Future SLR +2m
Mean High Water
Beach Nourishment

Mangrove Restoration & Migration

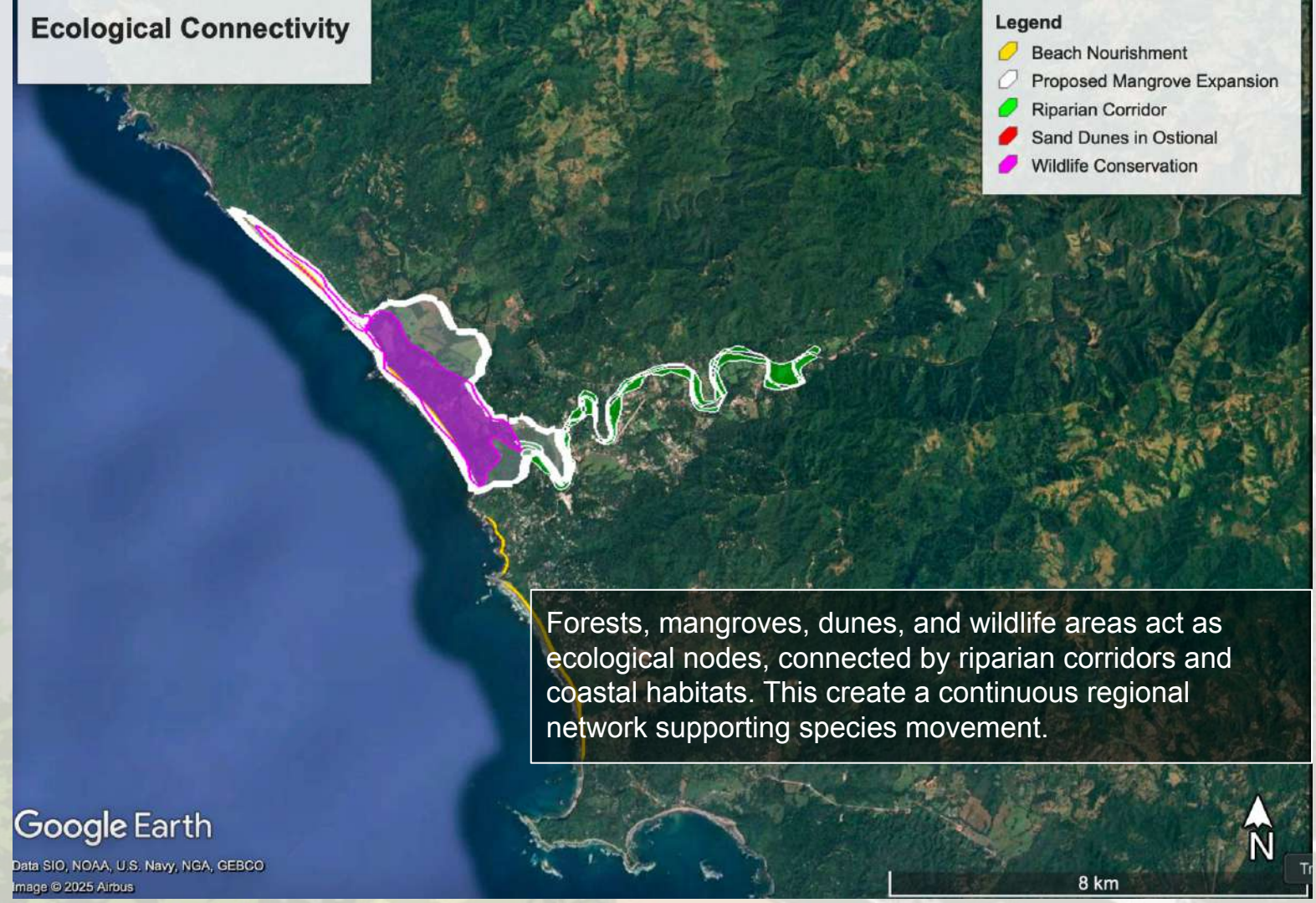
Channels cut to promote mangrove expansion

Reforestation of Watershed



Pagos por servicios ambientales (PSA) - Payment for Ecosystem Services (PES)

- *Increase native habitat & biodiversity*
- *Improve air and water quality*


Ecological Connectivity
Legend
Beach Nourishment
Proposed Mangrove Expansion
Riparian Corridor
Sand Dunes in Ostional
Wildlife Conservation
Forests, mangroves, dunes, and wildlife areas act as ecological nodes, connected by riparian corridors and coastal habitats. This create a continuous regional network supporting species movement.
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2025 Airbus
N
8 km

N
1 km

Green - Riparian Corridors + Levees

- Absorb excess floodwater
- Filters sediments and contaminants
- Creates habitat for wildlife

Image Generated with Gemini

Green - Floodplain Parks

- Entertainment
- Leisure-time hangout
- Absorbs seasonal flooding

Green - Floodplain Parks

Plan

Rough illustration

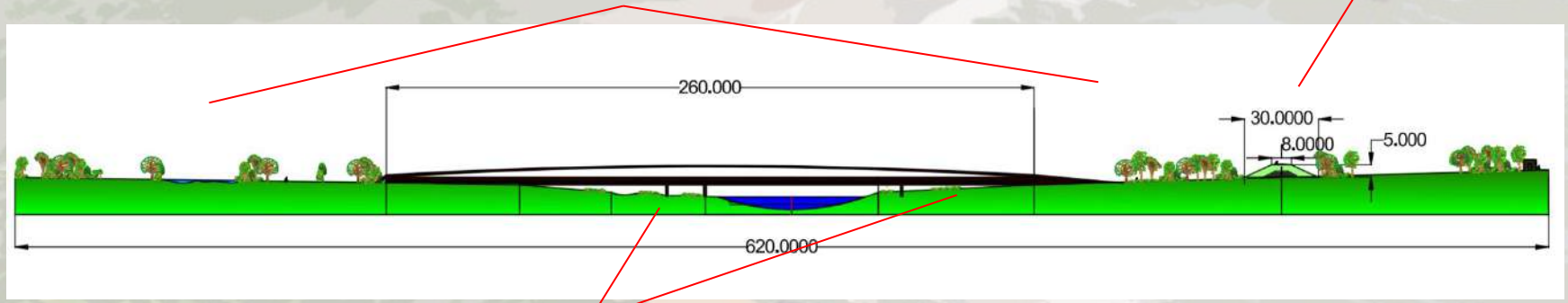
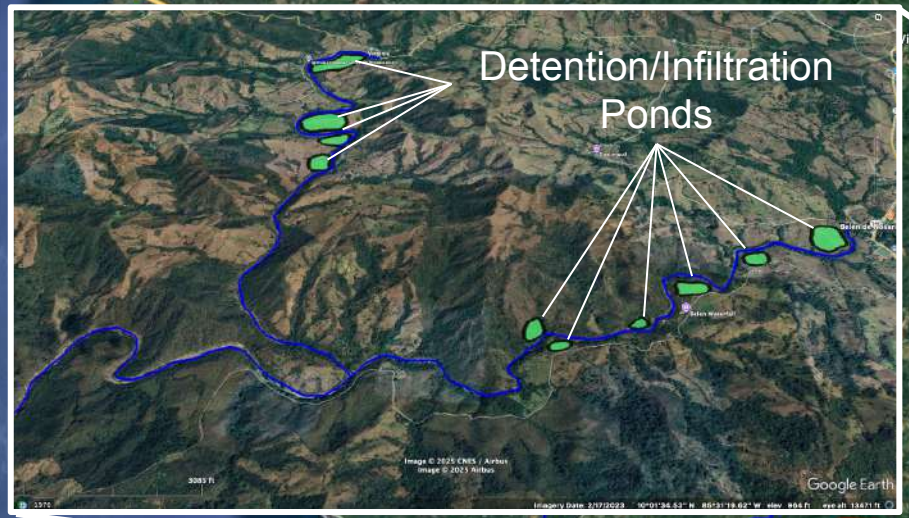
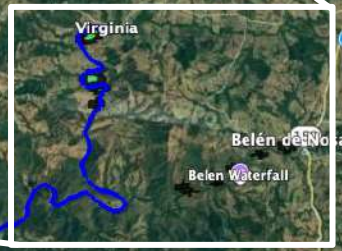


Image Generated with Gemini

Blue - Upstream Watershed Detention Ponds



- Mitigates downstream flooding
- Recharges groundwater
- Catches contaminants upstream



Blue - Water Retention Ponds

- Collects rainwater for use
- Recharges groundwater
- Absorbs floodwater

Blue - Wetland

Slows and filters sediment from upstream flow

Blue - Water Treatment Facility

- Small scale
- Treats upstream water
- Returns clean water to river

Grey - Wastewater Transport & Treatment

Wastewater Treatment

Lift Station

- Centralized
- Flat, flood-safe location
- Supports groundwater recharge

Image Generated with Gemini

Roads at Risk (2m SLR + High Rainfall)

Possible Road Rerouting

Highway / Transmission Re-routing

New Highway:
- Length: 2.52mi
- Avg Slope: 2.7%, -3%
- Max Slope: 10.0%, -8.6%:

Road to Next Town:
- Length: 2.66mi
- Avg Slope: 5.1%, -4.4%
- Max Slope: 18.9%, -16.6%:

Existing Highway:
- Length: 2.47mi
- Avg Slope: 2.1%, -2.2%
- Max Slope: 7.5%, -9.4%:

Electric Transportation Hub

- Off Main Highway
- Central between Nosara, Ostional, Guiones
- Supports Regional & Local
- High-Powered Charging

Image Generated with Gemini

Regional Express

- Access major airports
- Access nearby cities
- Electric

Image Generated with Gemini

Coastal Route

- Affordable
- Reliable
- Clean
- Expands local housing and jobs

Local Autonomous Shuttles

Image Generated with Gemini

- High-frequency
- Reliable
- Affordable
- Quiet & Clean
- Connects the community

Electric Bike-Share

- Easy Access
- Low-Cost
- Fun
- Safe

Image Generated with Gemini

Integrated Trail Network

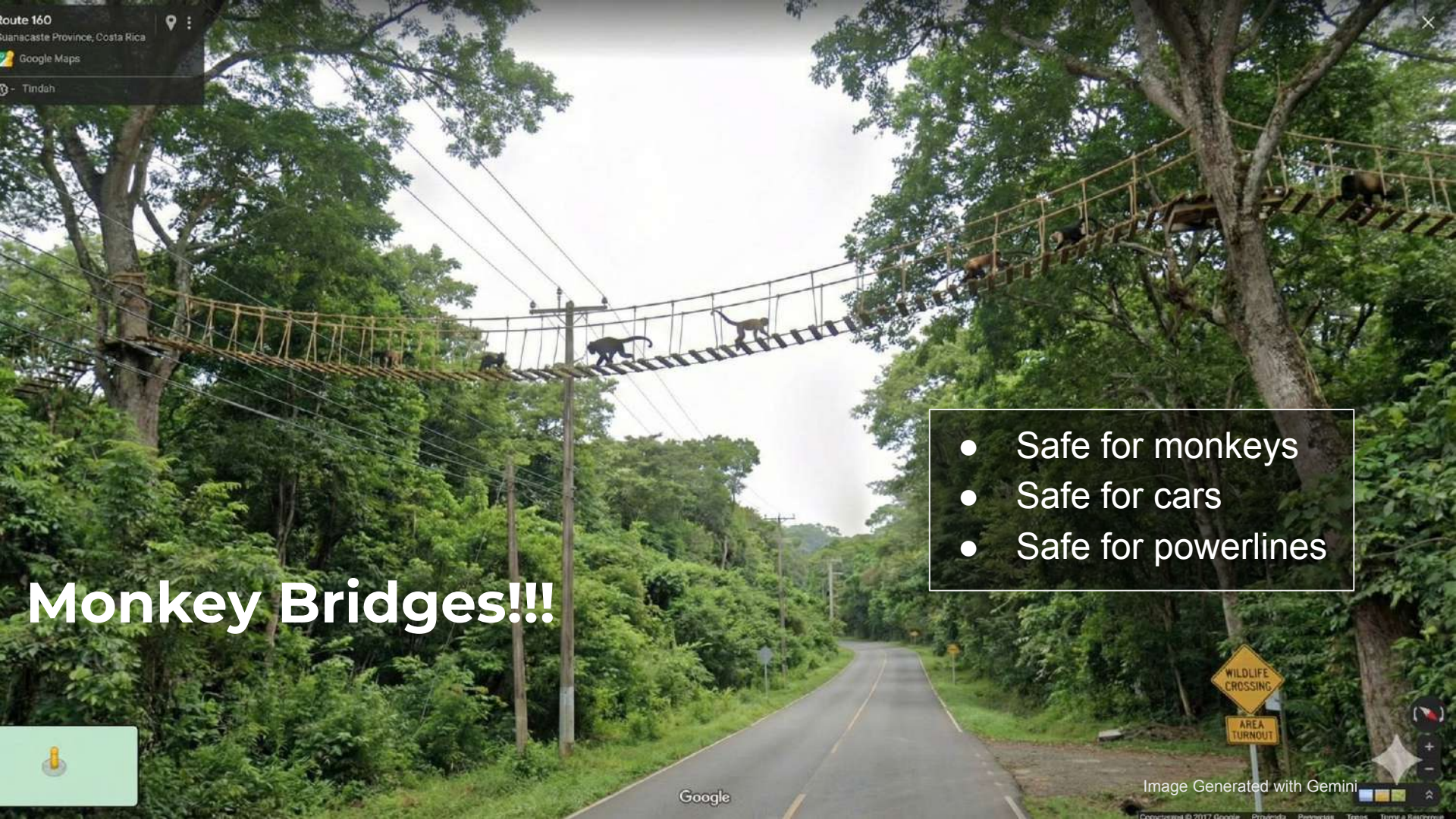
- Connect community
- Enjoy green space
- Good for health
- Connect to nature
- Bike & walk

Images Generated with Gemini

Vertical Takeoff Airport

- More space for the community
- Quieter
- Less polluting
- Can operate during floods

Image Generated with Gemini

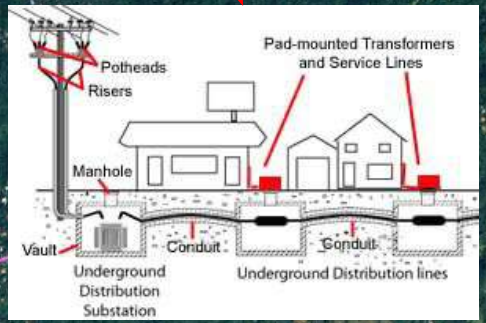

Route 160
Guanacaste Province, Costa Rica
Google Maps
- Tindah
Monkey Bridges!!!
Safe for monkeys
Safe for cars
Safe for powerlines
WILDLIFE CROSSING
AREA TURNOUT
Google
Image Generated with Gemini

Energy

Legend
- Distribution Line
- Solar Panel on Rooftop

- Solar Rooftop is deployed
- Multipurpose for rainwater harvesting
- Second-life battery storage

- Net-Billing Tariff (NBT) for residences
- Underground distribution substation & lines



Google Earth

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2025 Airbus

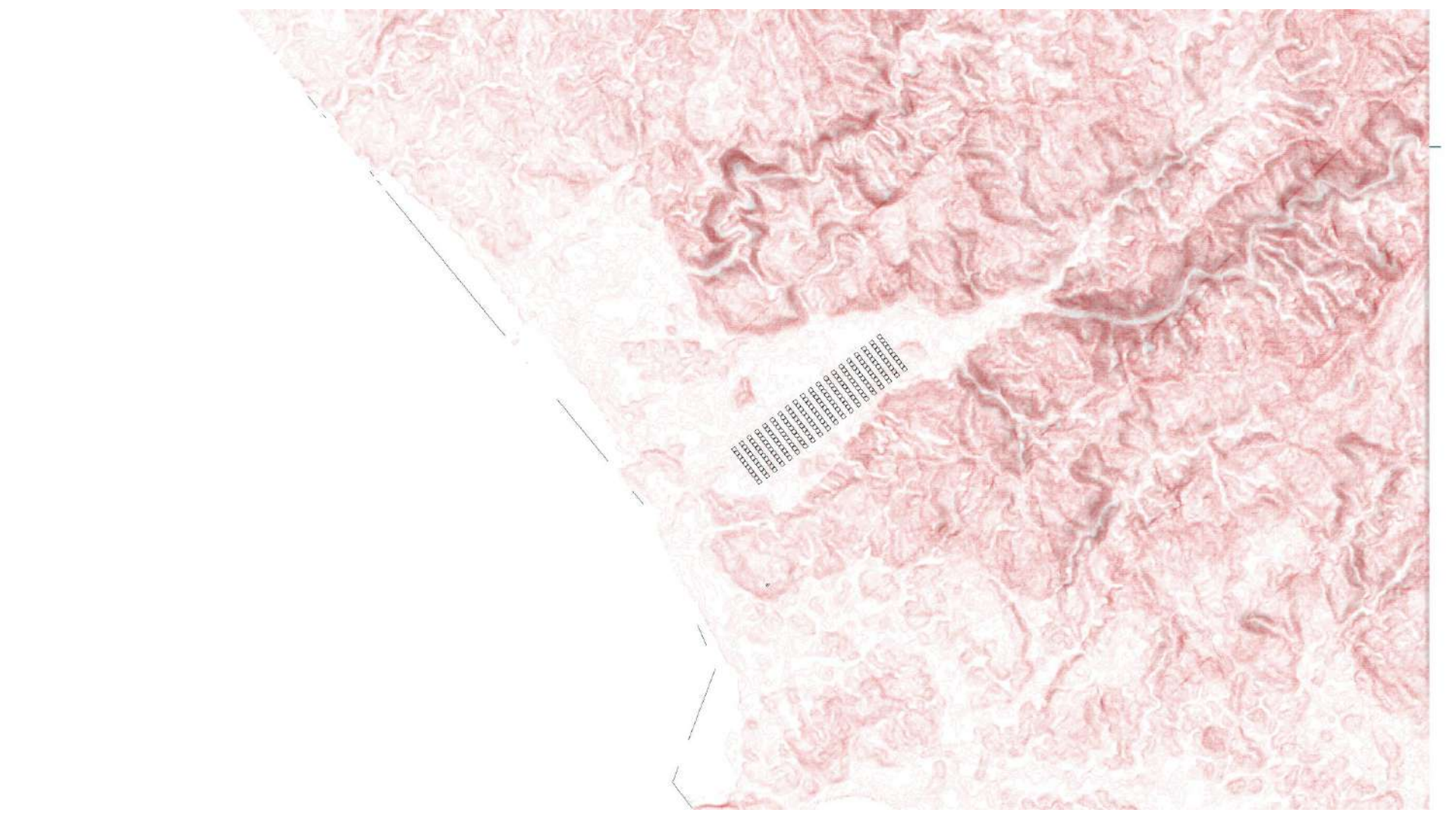
N

3 km

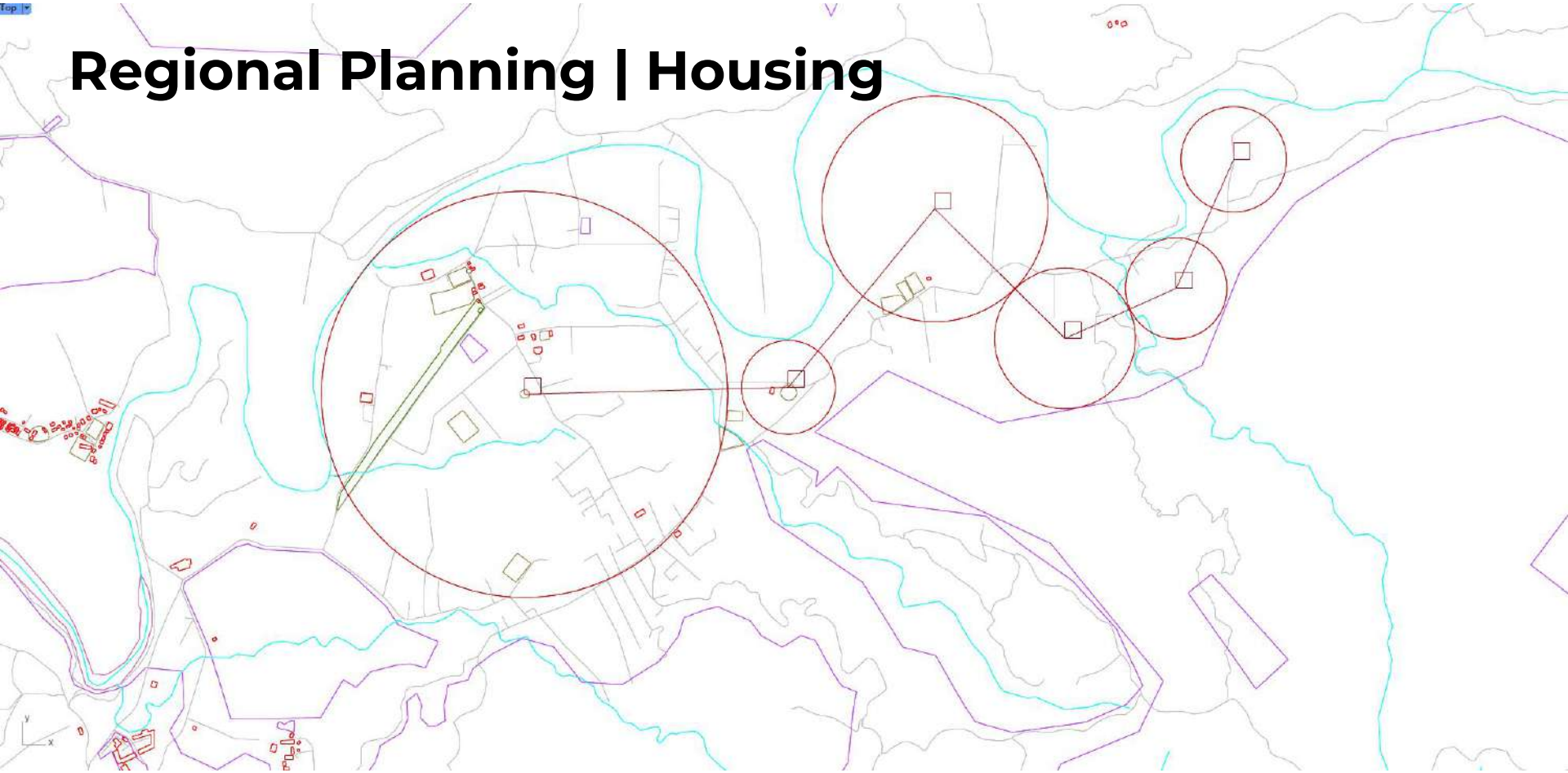
Regional Planning | Housing

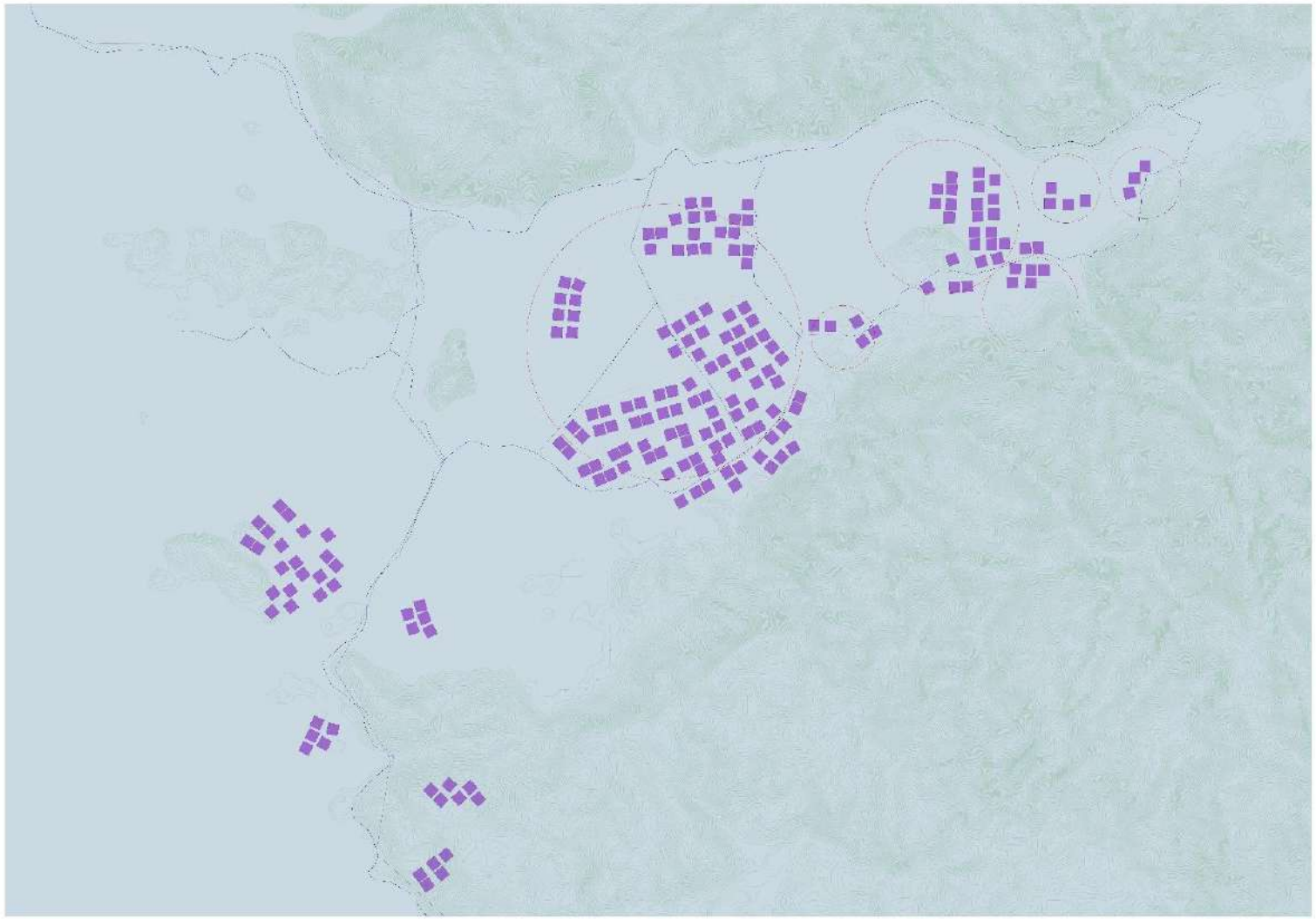
Current Development

Scale 1:10000



Regional Planning | Housing

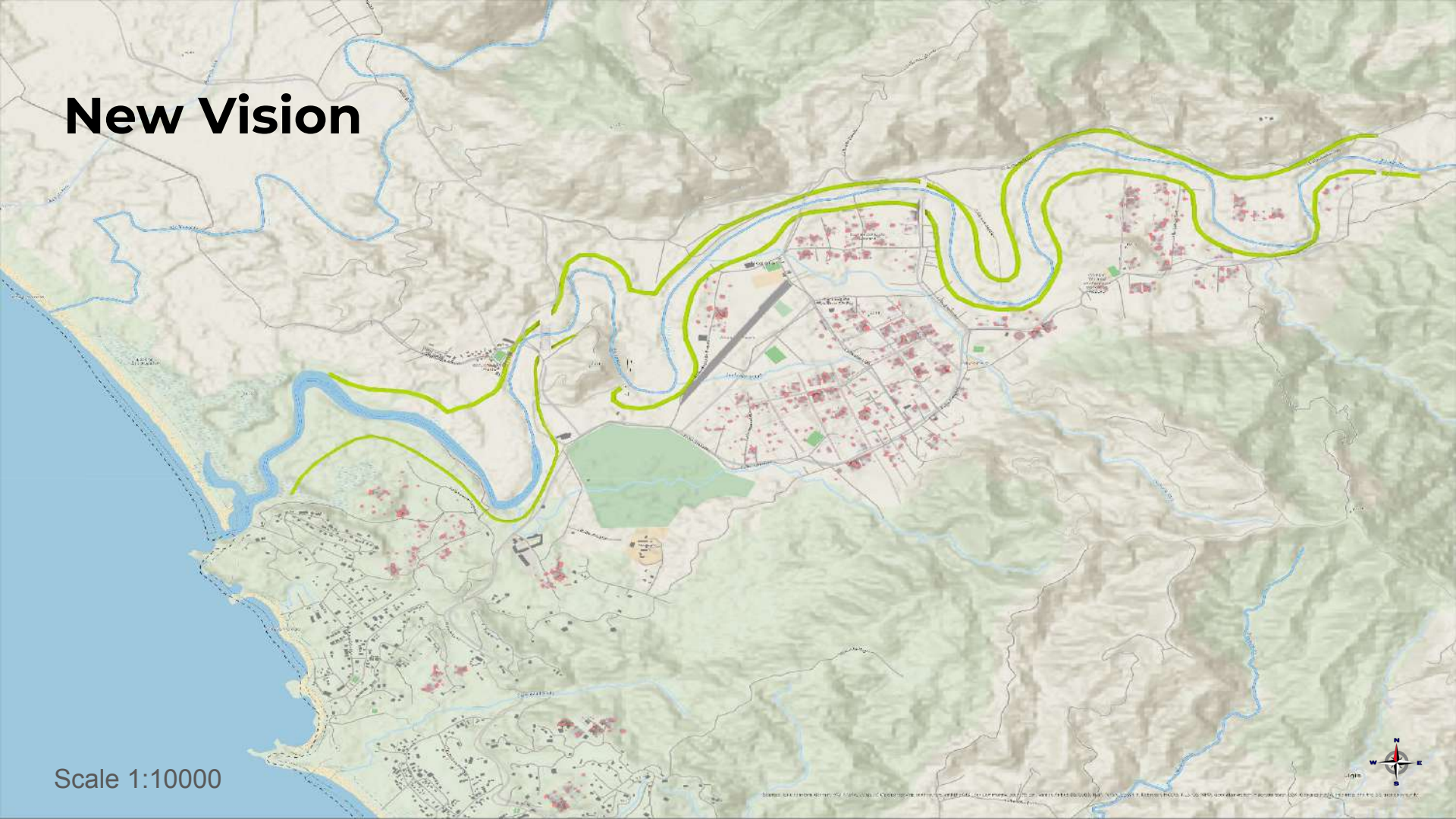




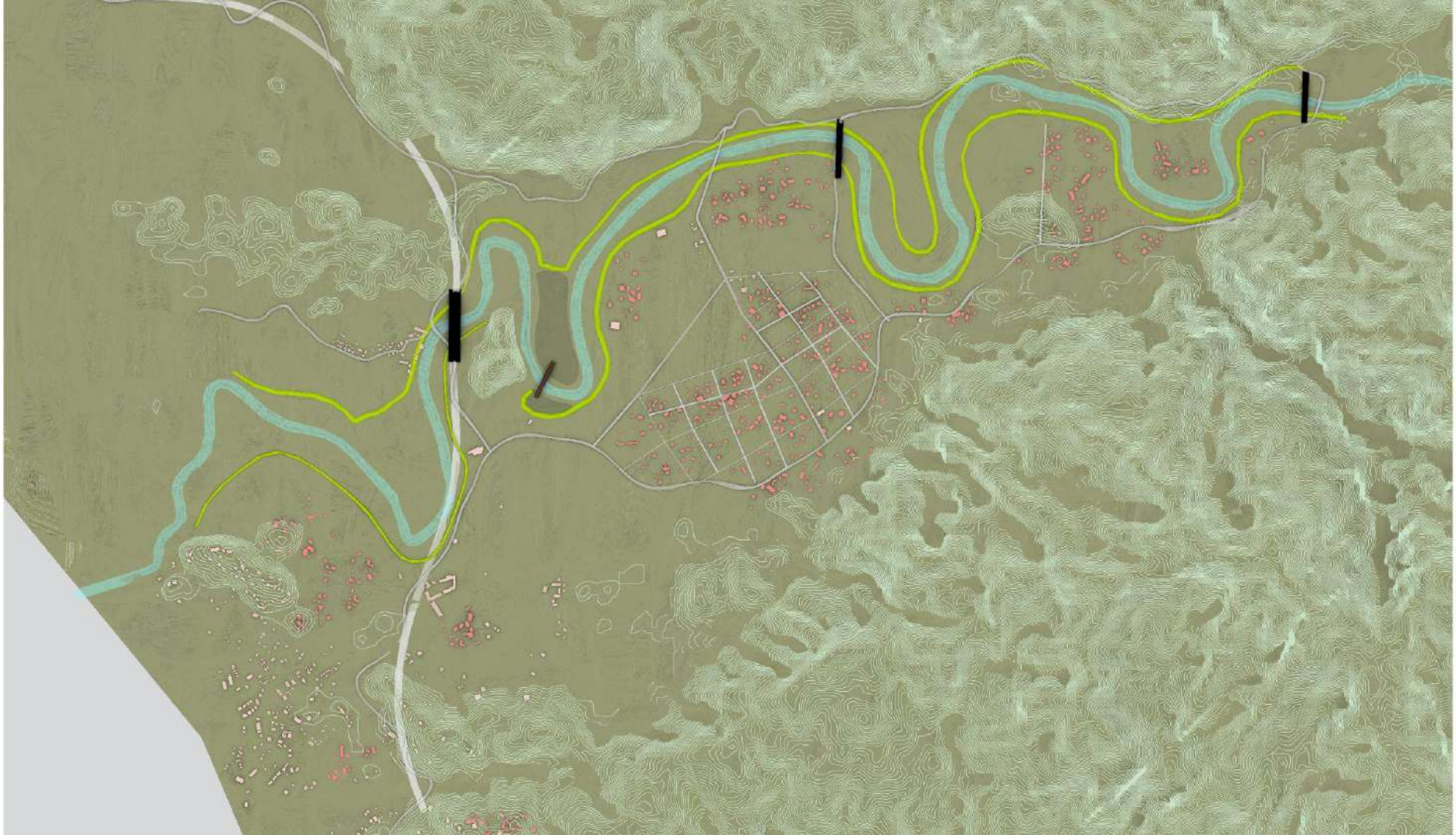
Current Development

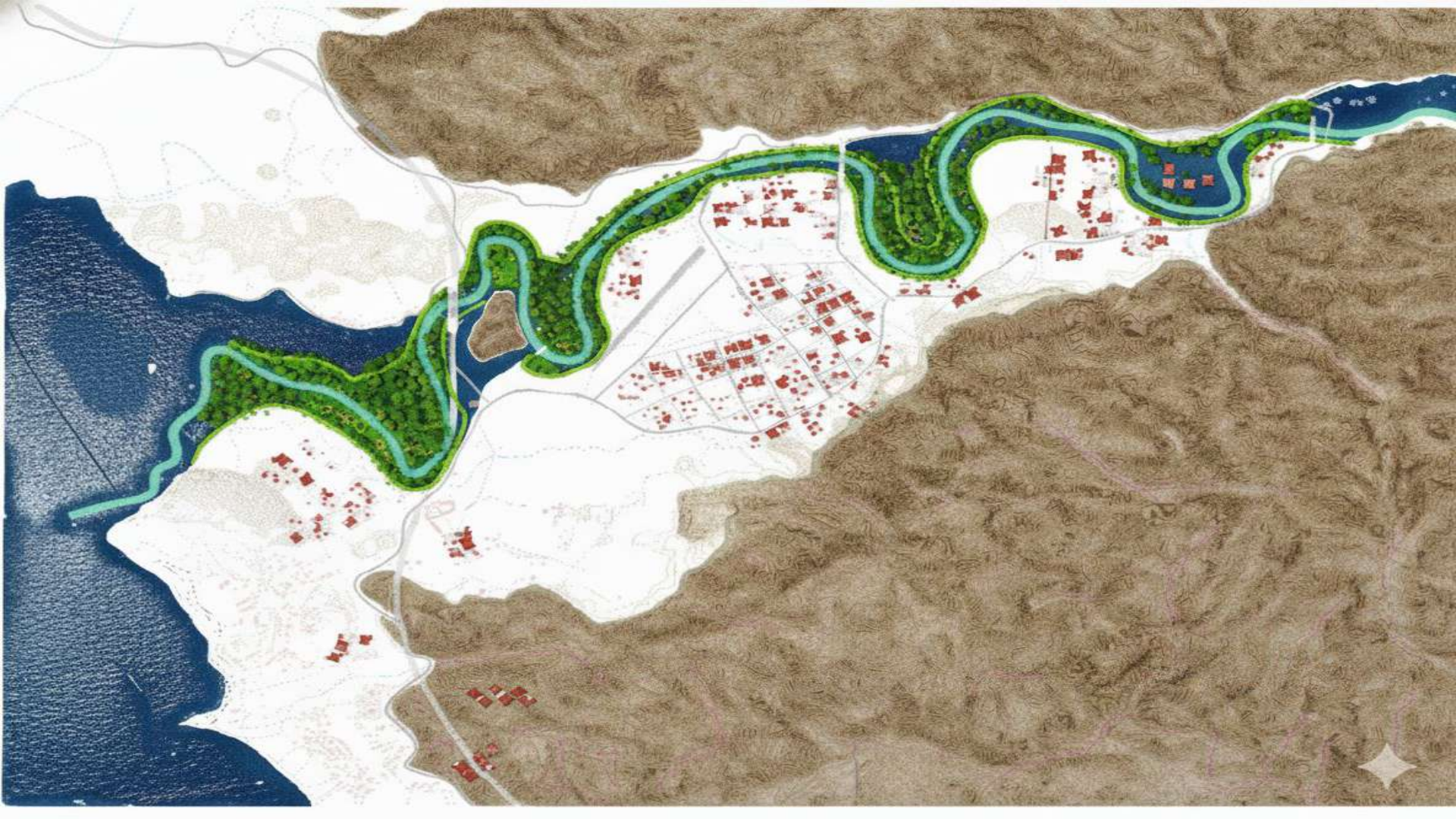
Scale 1:10000

New Vision

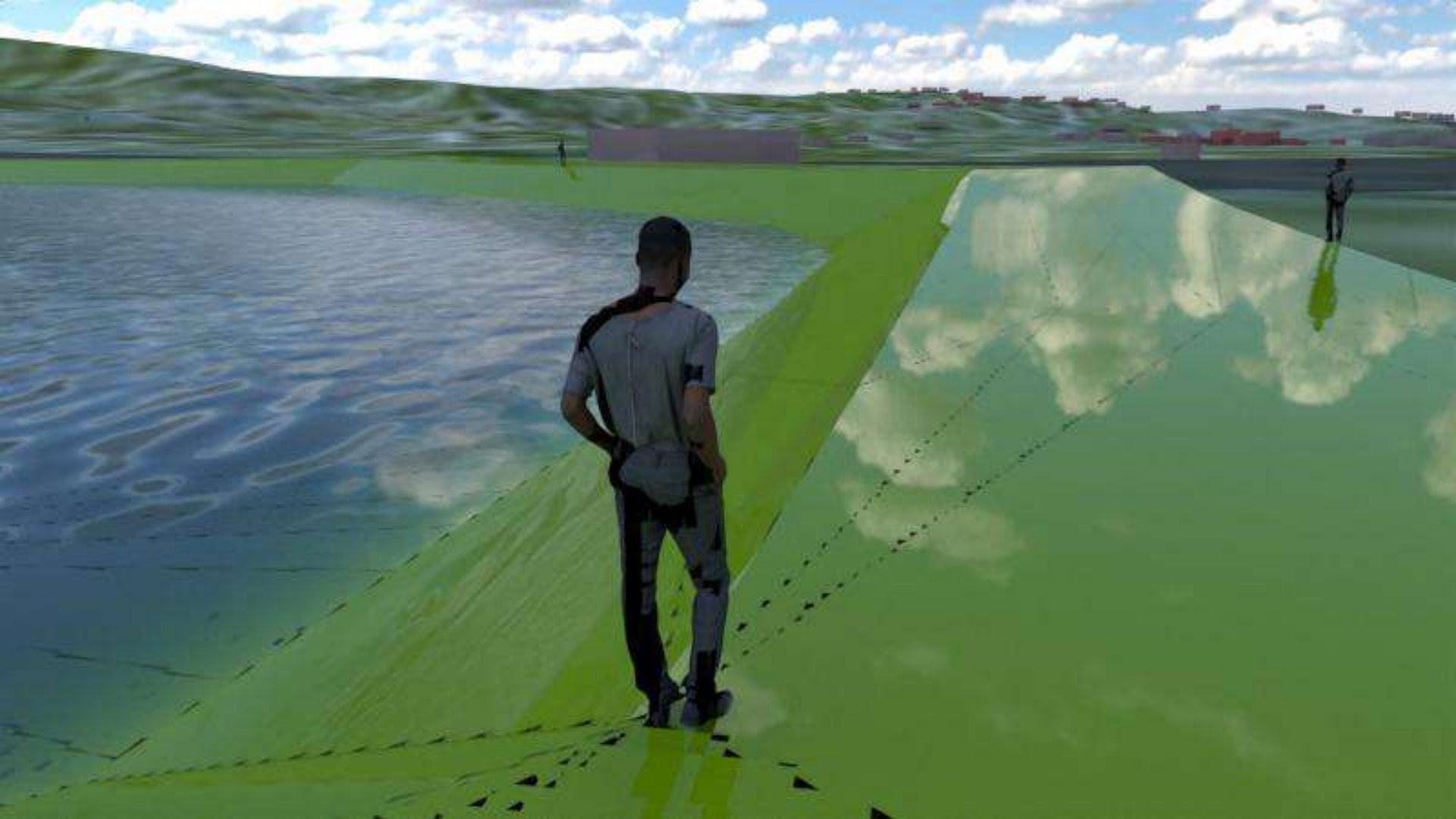


Scale 1:10000

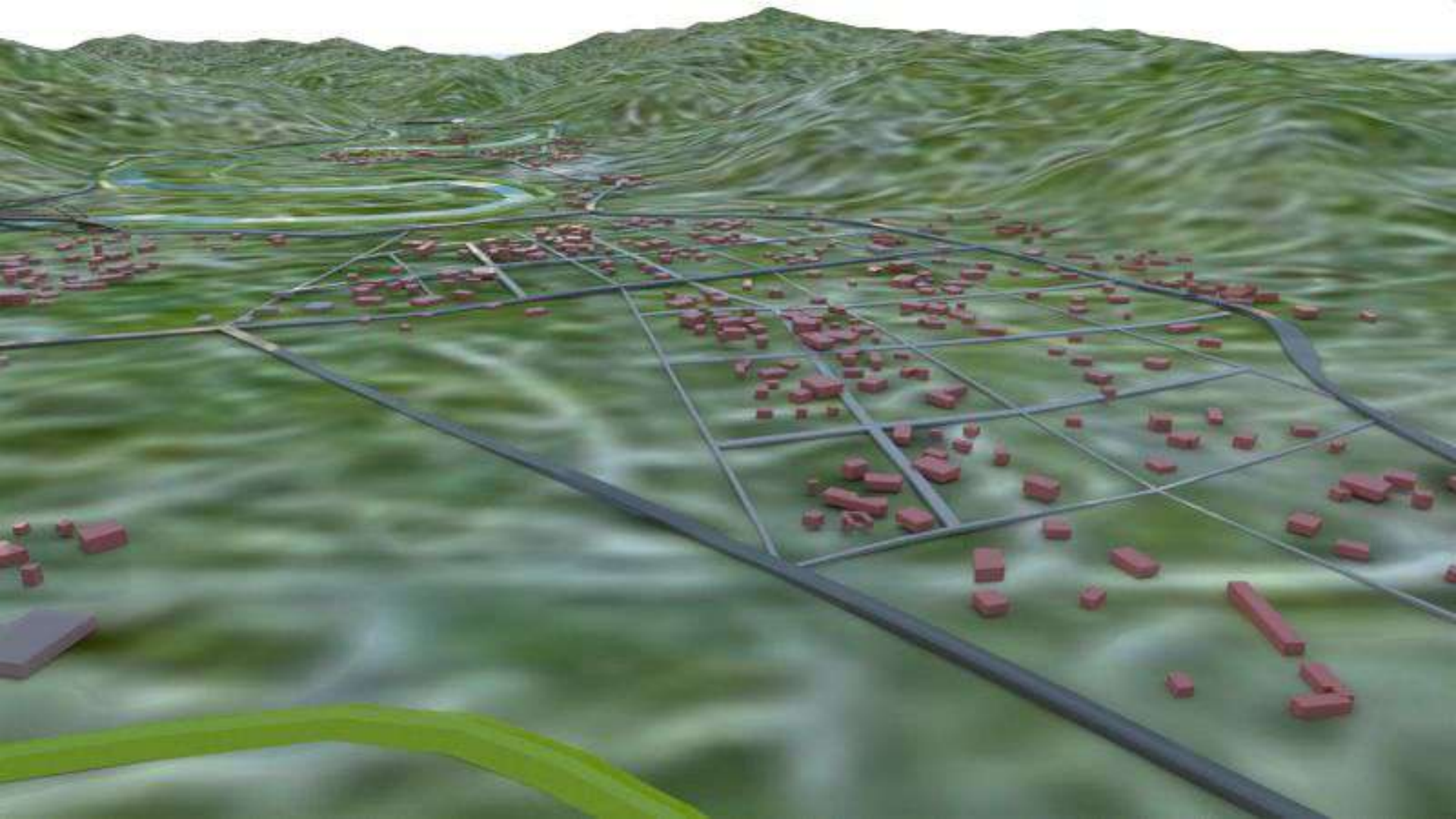


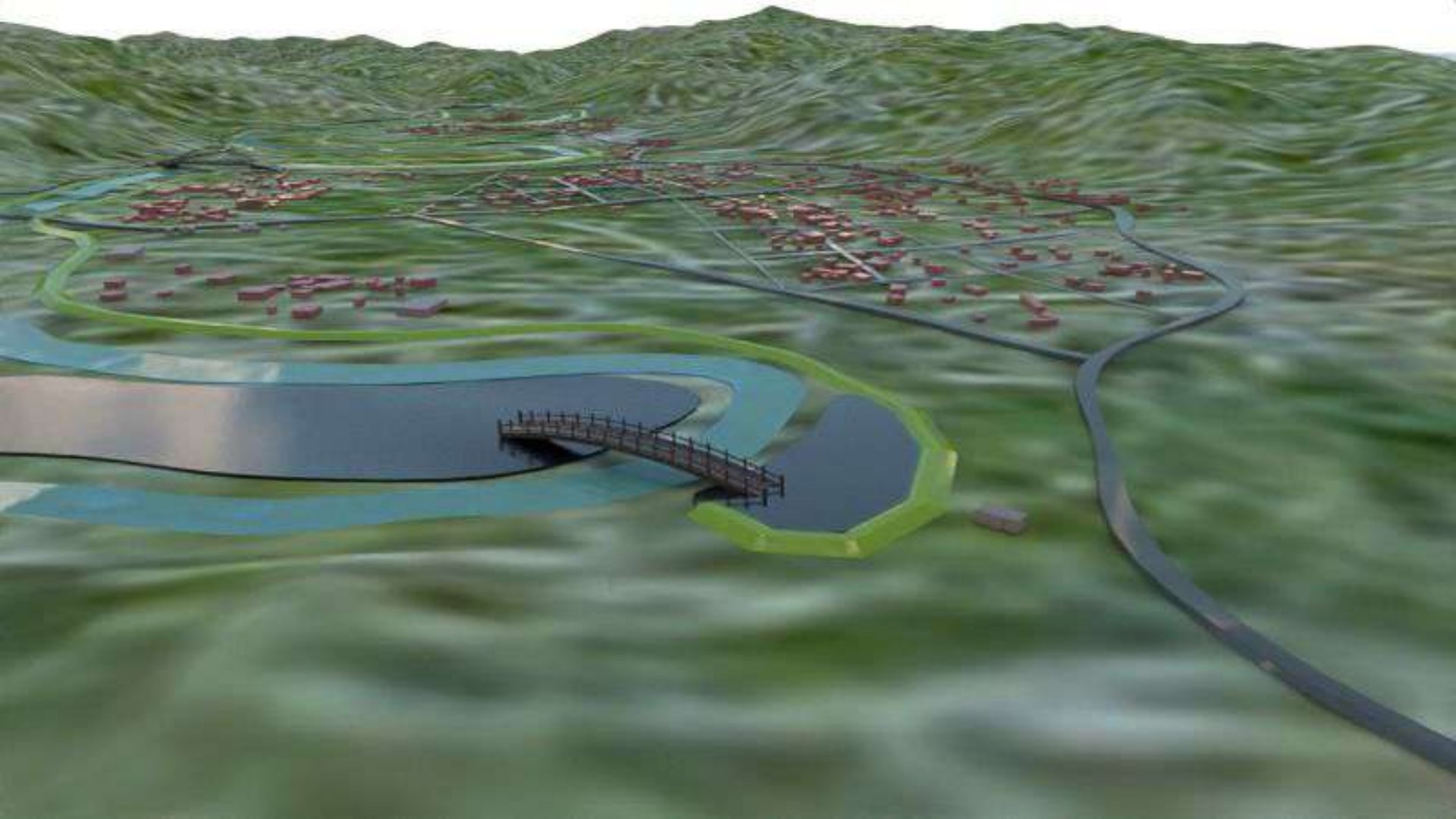


Block Type	Density Level	# Blocks	Approx Units / Block	Total Units
L1 / L2	Low	**120**	~8 units	**960**
M1 / M2	Medium	**80**	~20 units	**1,600**
TOTAL	—	**200**	—	**2,560**

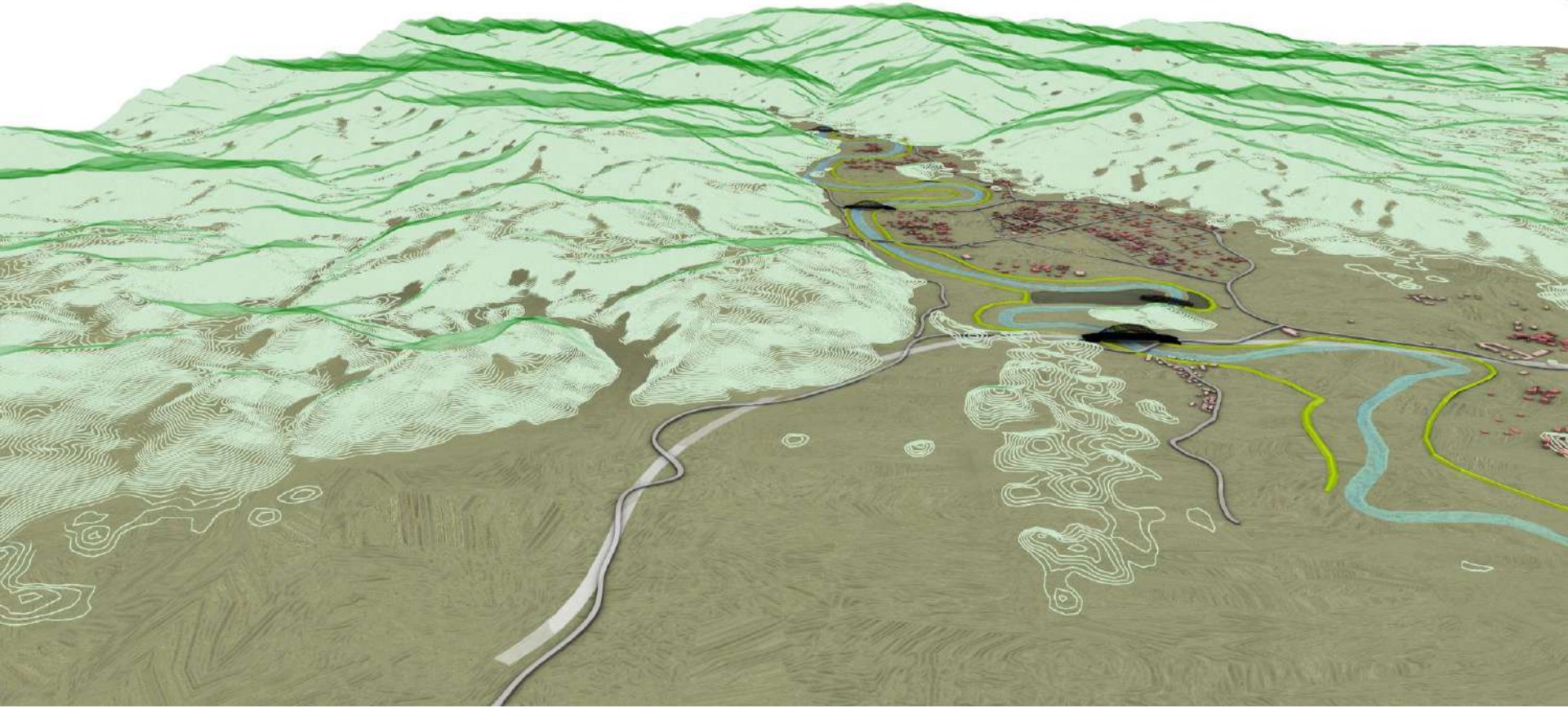


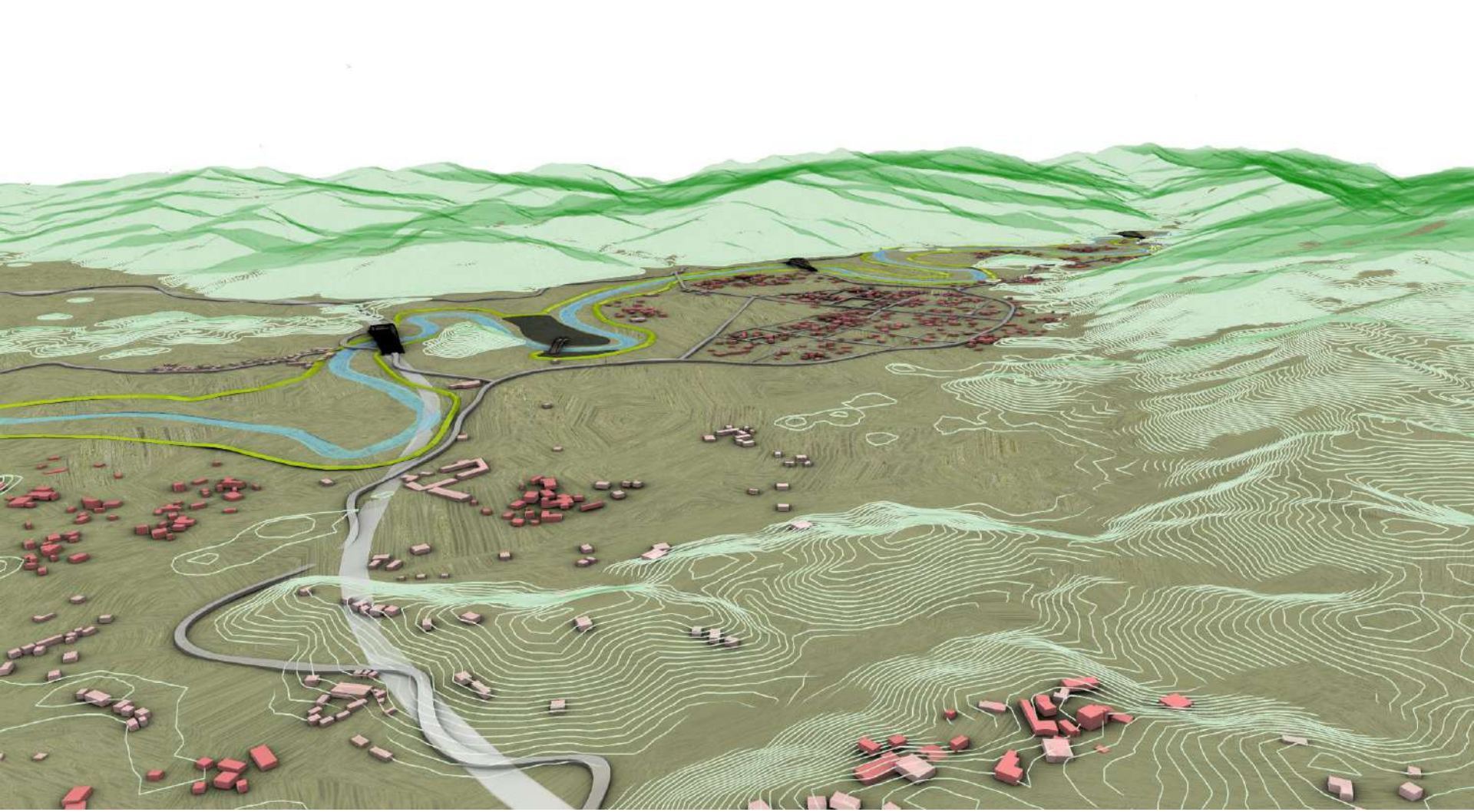

Google Earth

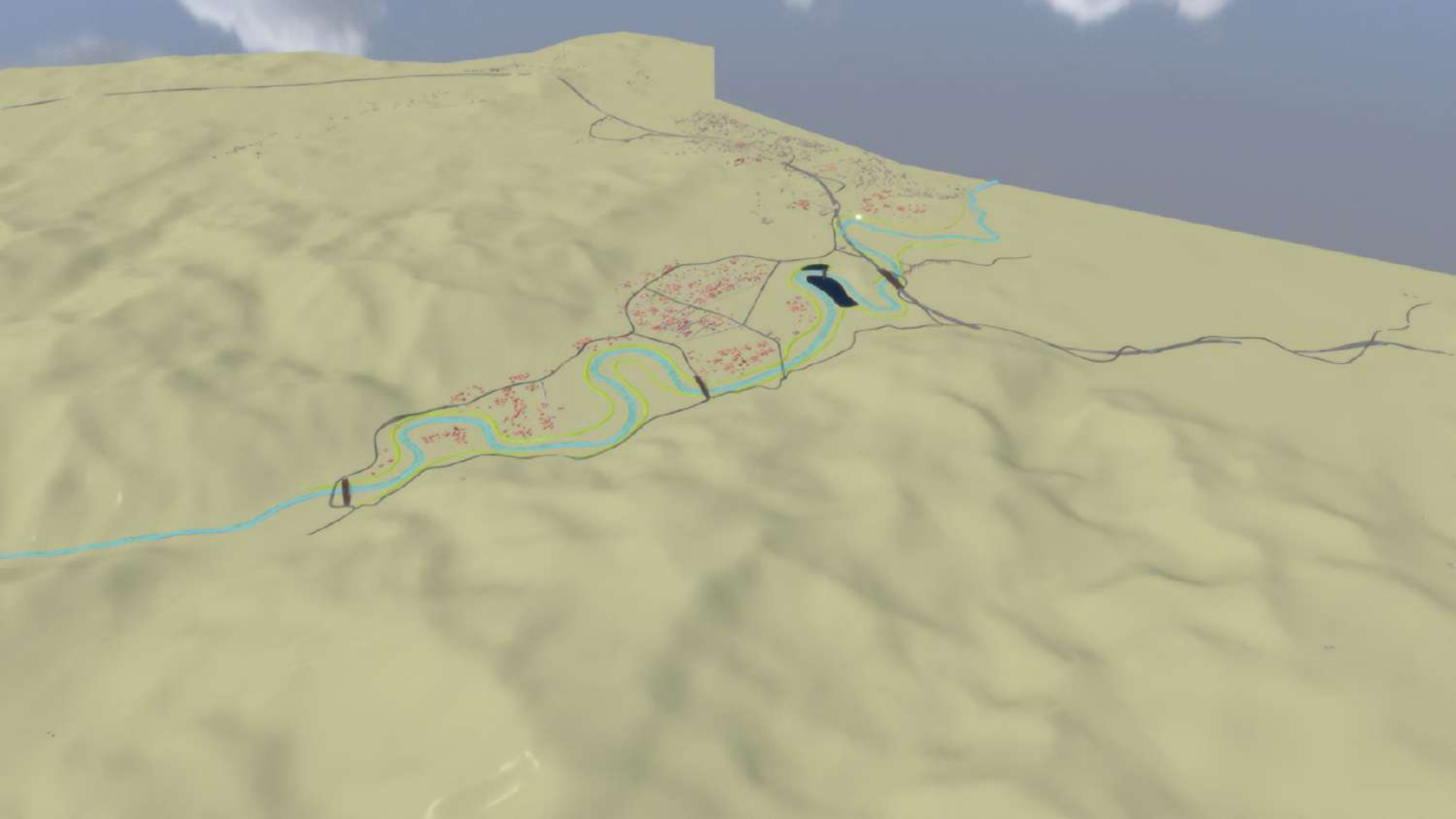




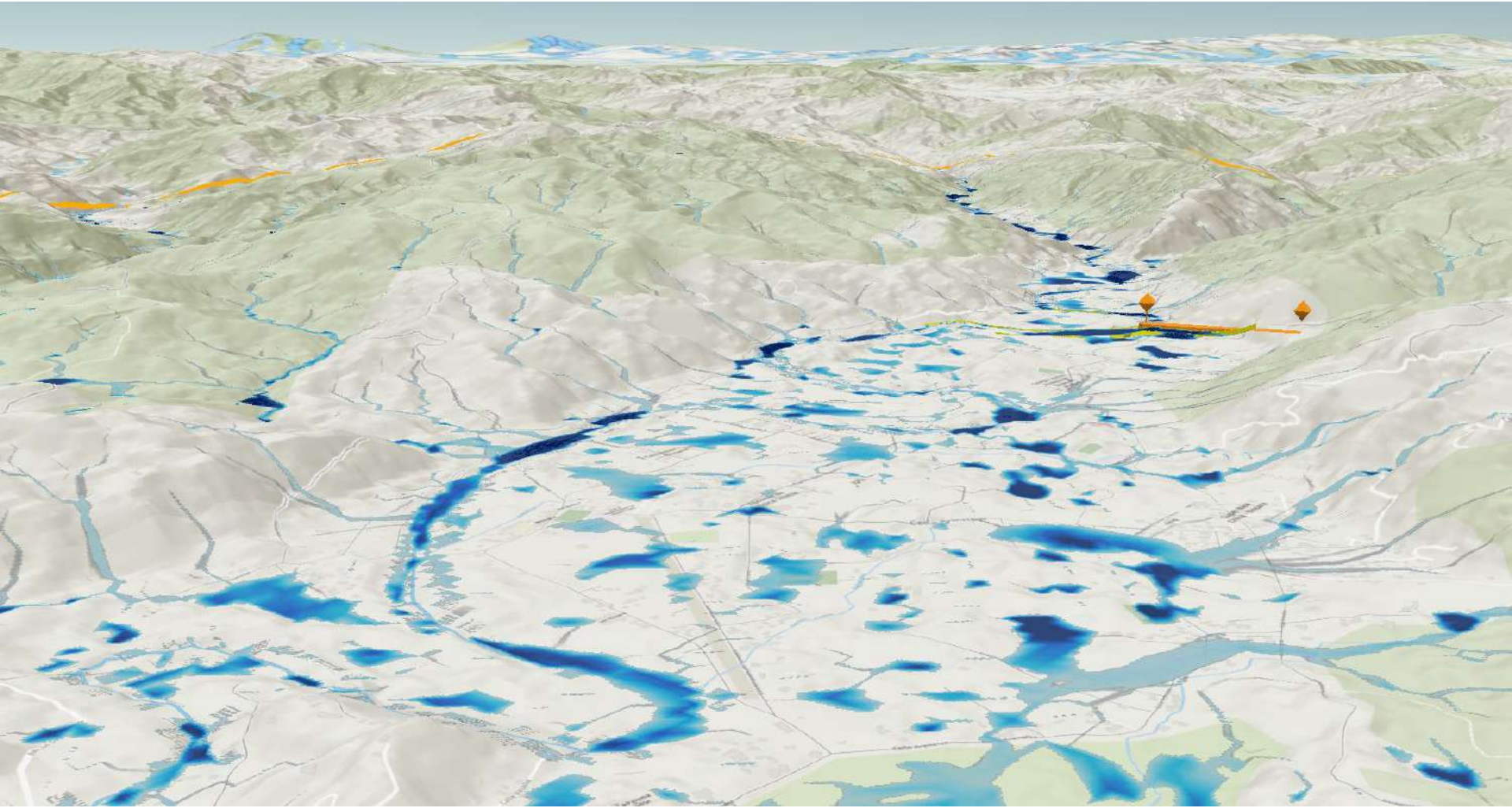
Model Development - 1 Rhino - Vray Workflow

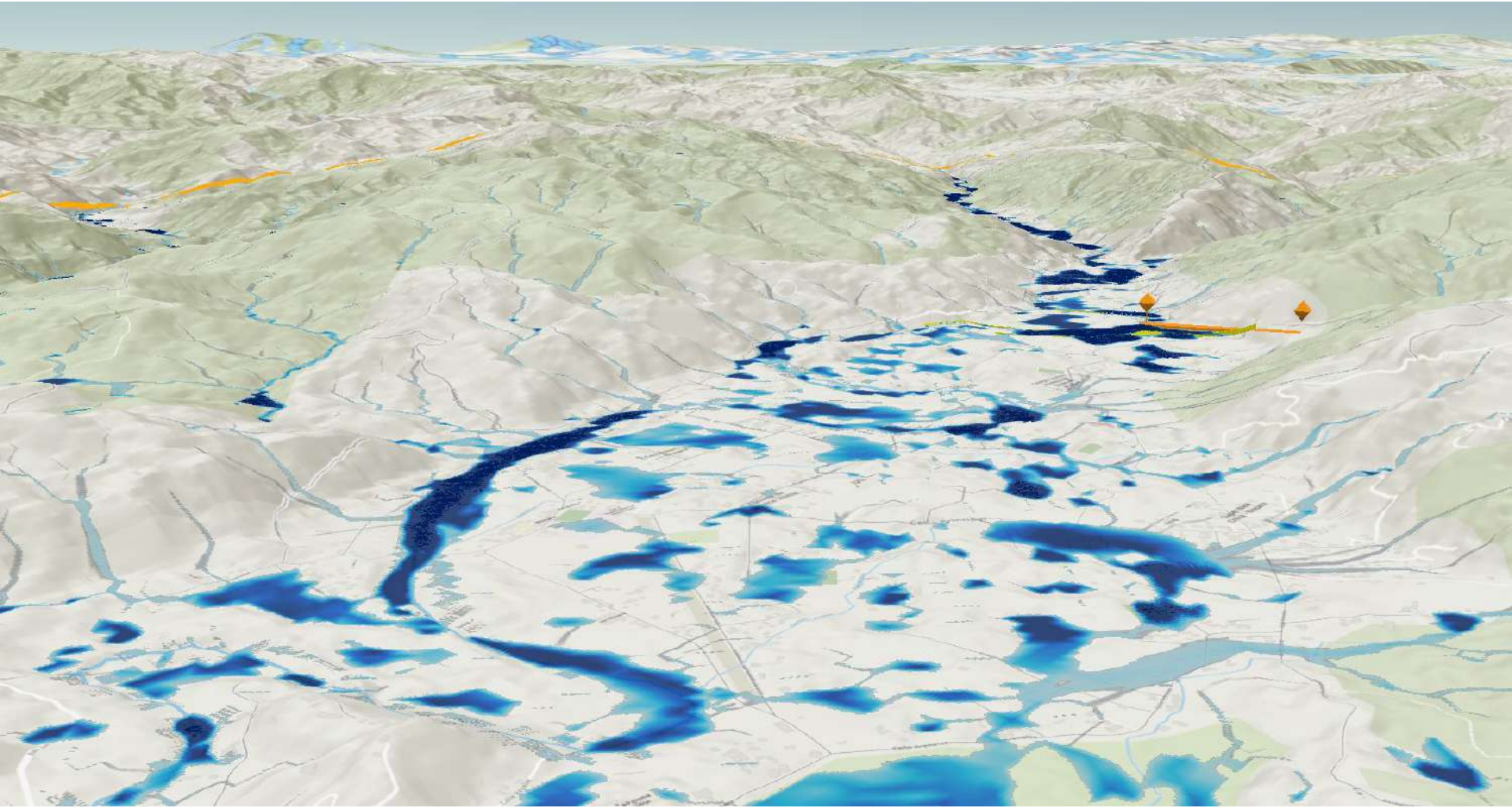






Model Development -2 Arcgis Animation






Thank you!

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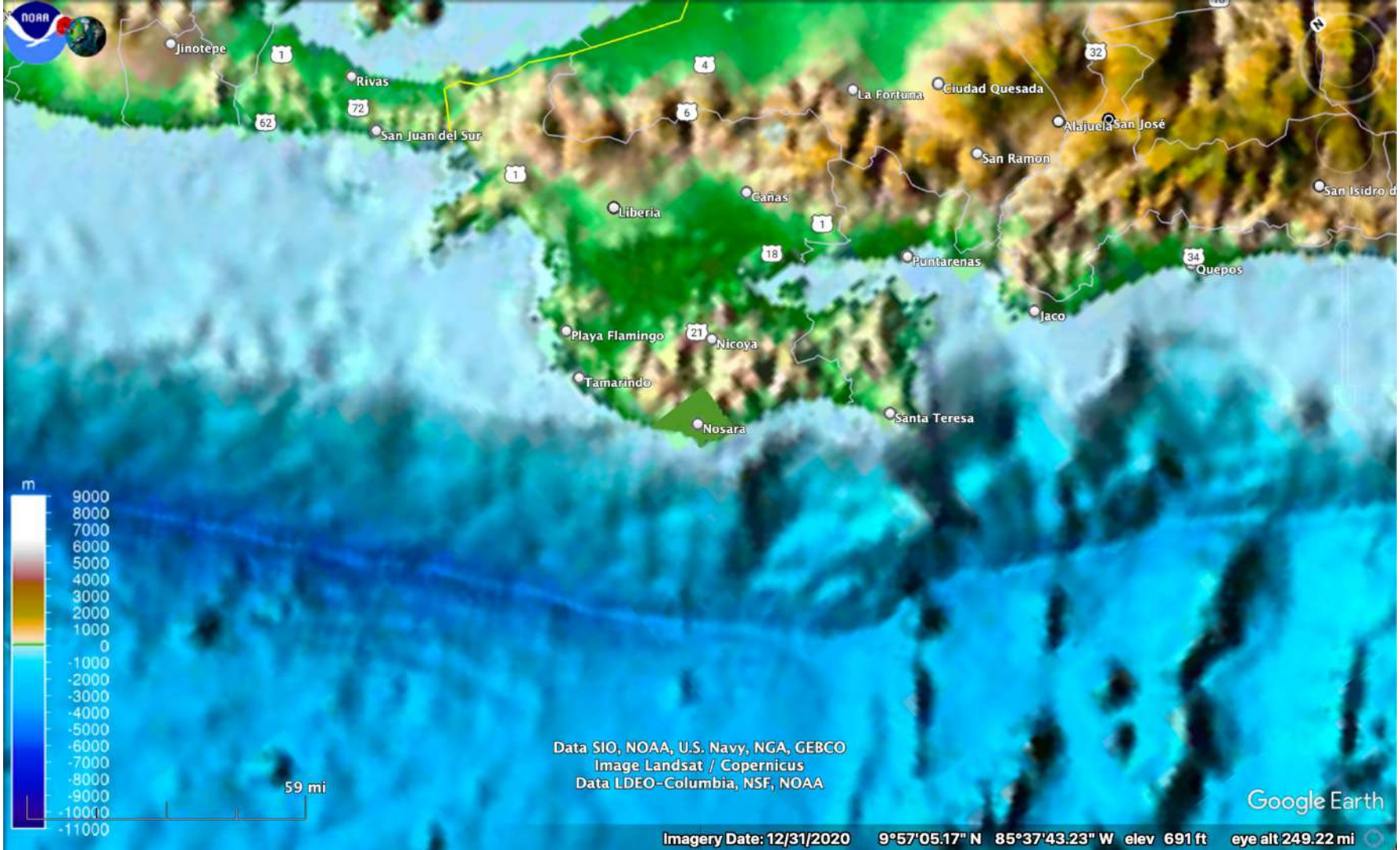
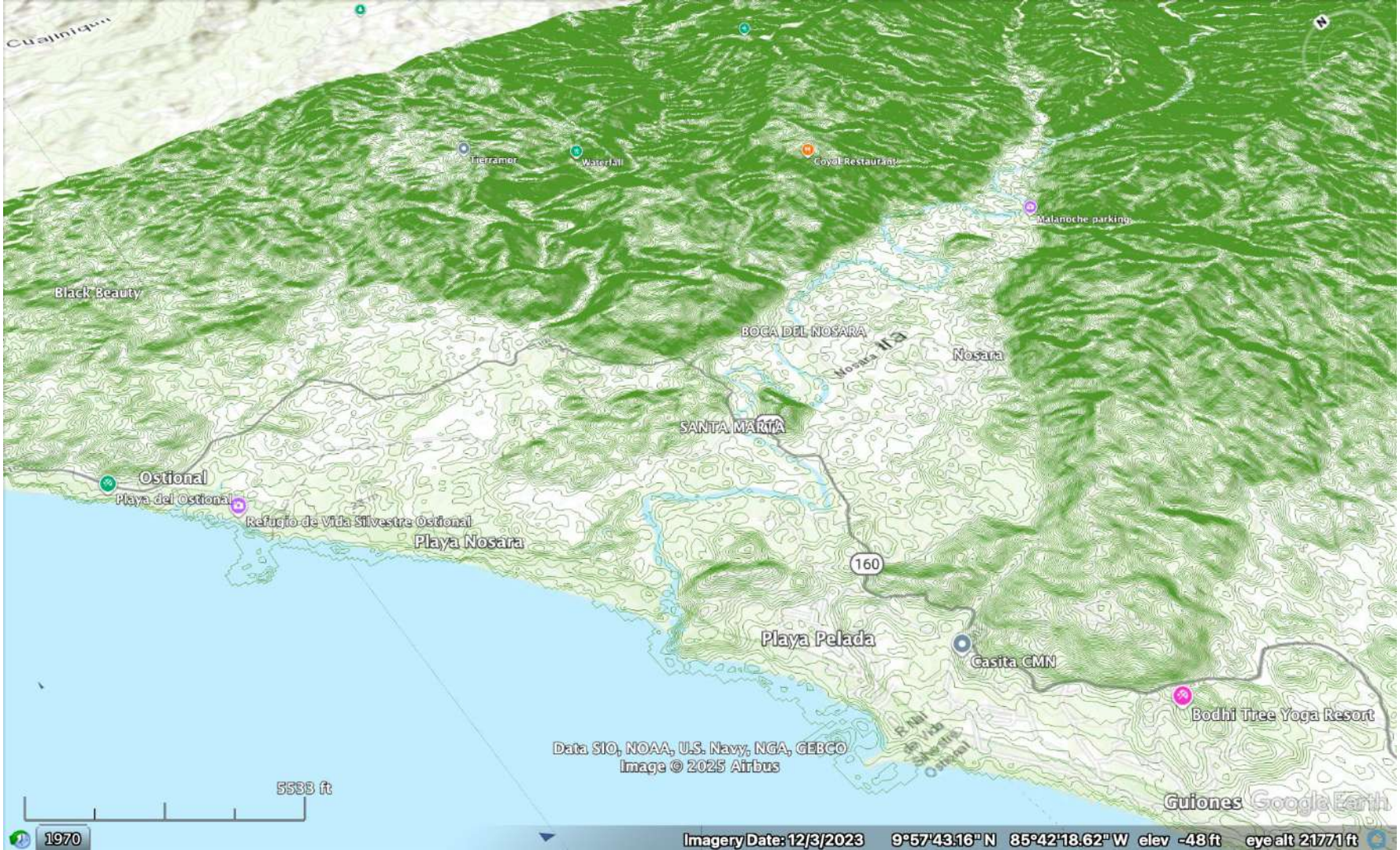
Appendices

Appendix A: Context


Jinotepe
Rivas
San Juan del Sur
La Fortuna
Ciudad Quesada
Alajuela
San José
San Ramon
Cañas
Liberia
Puntarenas
Quepos
Jaco
Playa Flamingo
Nicoya
Tamarindo
Nosara
Santa Teresa
m
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10000
-11000
59 mi
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Data LDEO-Columbia, NSF, NOAA
Google Earth
Imagery Date: 12/31/2020 9°57'05.17" N 85°37'43.23" W elev 691 ft eye alt 249.22 mi

Vulnerable zones: housing, infrastructure, ecology

1. **Ostional (Ecologial Preserve)**: Rising seas threaten vital turtle nesting habitats.
2. **Nosara City (Local Settlement)**: Flooding endangers homes, roads, and local livelihoods.
3. **Beachfront (Tourism)**: Erosion and storms jeopardize tourism and coastal businesses.


Tierramor
Waterfall
Coyal Restaurant
Malanoche parking
Black Beauty
BOCA DEL NOSARA
Nosara
SANTA MARTA
Ostional
Playa del Ostional
Refugio de Vida Silvestre Ostional
Playa Nosara
160
Playa Pelada
Casita CMN
Bodhi Tree Yoga Resort
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2025 Airbus
5533 ft
Guiones
Google Earth
1970
Imagery Date: 12/3/2023 9°57'43.16" N 85°42'18.62" W elev -48 ft eye alt 21771 ft

Appendix B: Vision

Principles

Energy Abundance

Protect Wildlife & Habitat

Equitable Growth

Climate Resilient

NOSARA

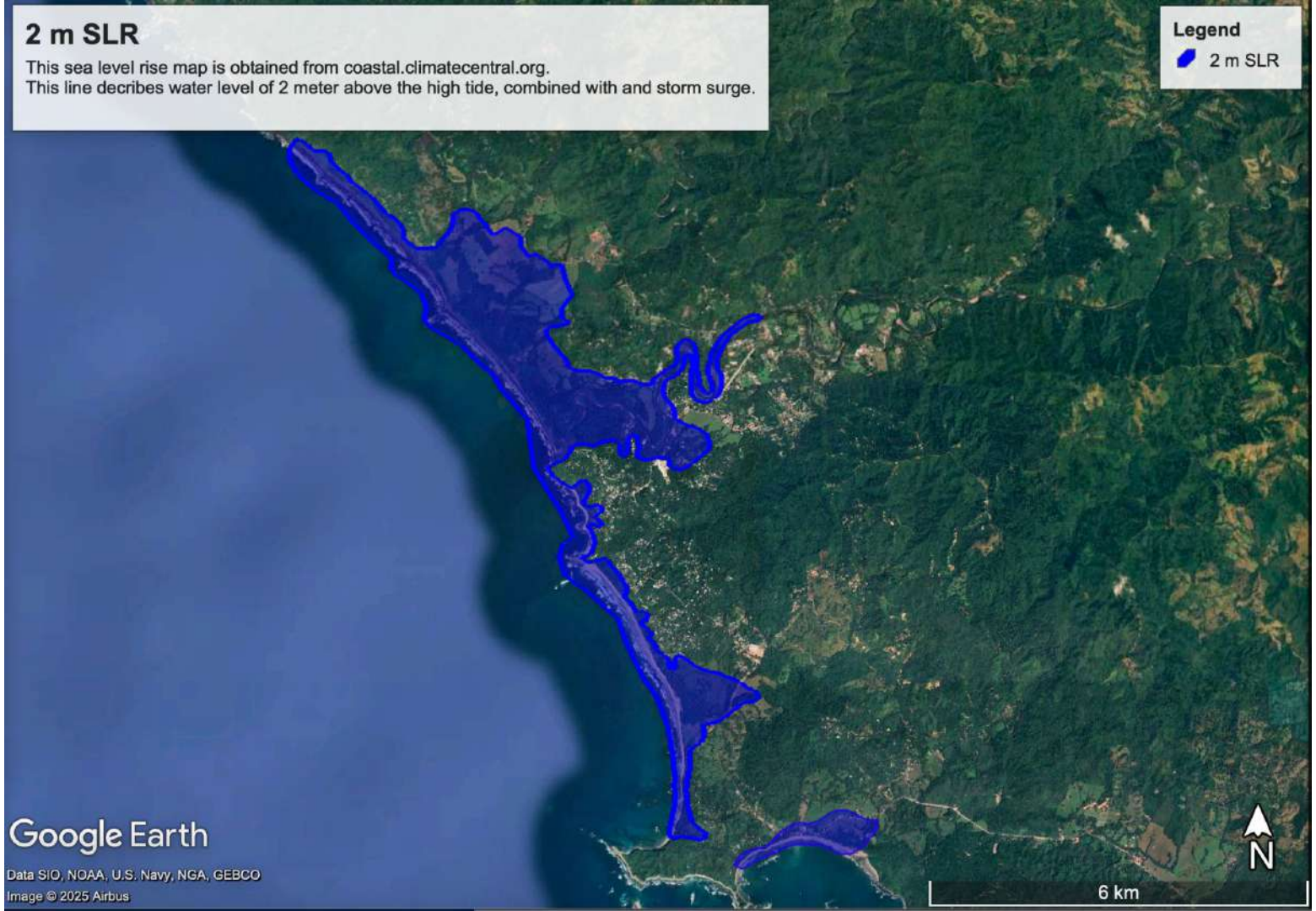
Clean Water, In and Out

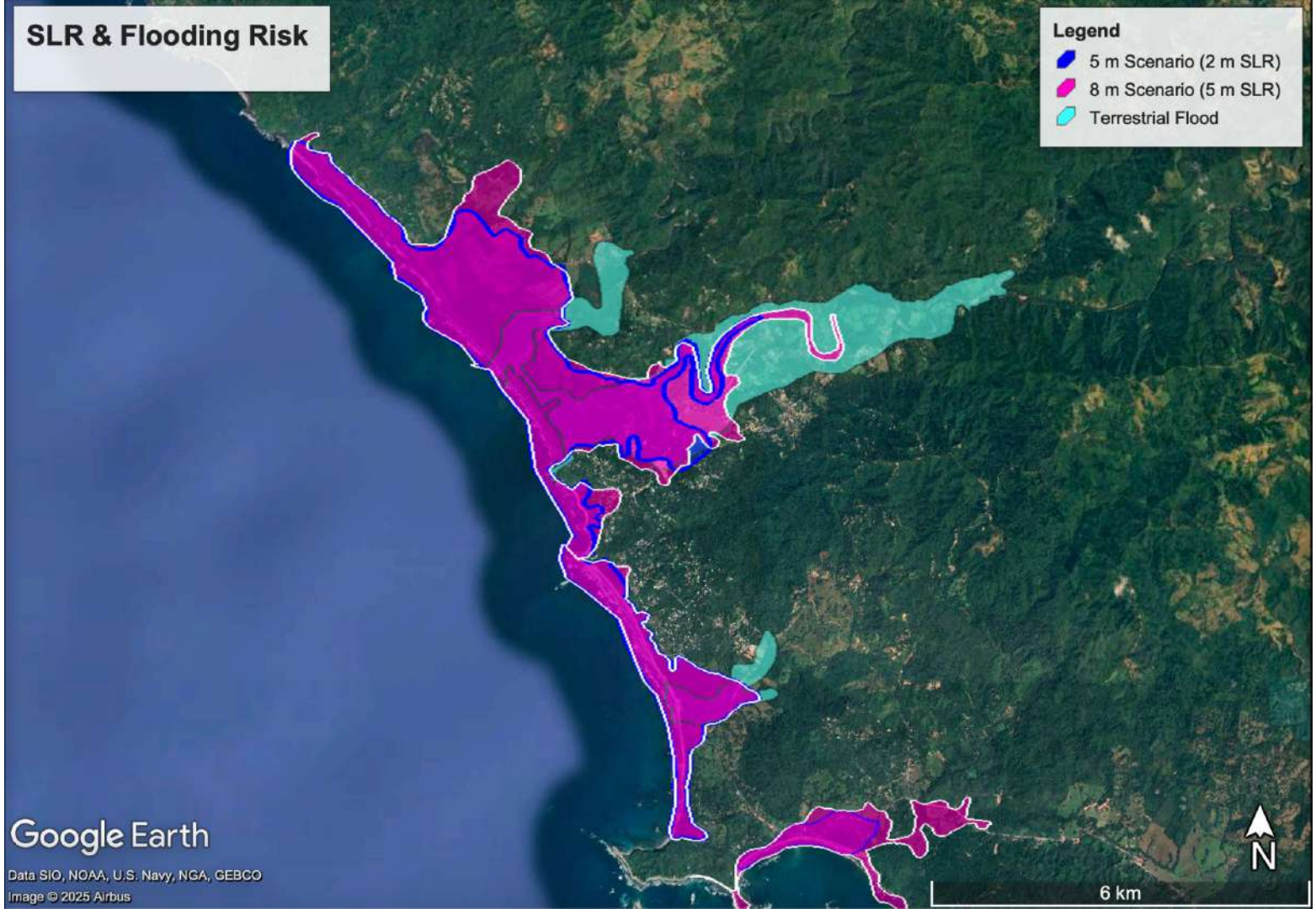
Build in the Image of Nature

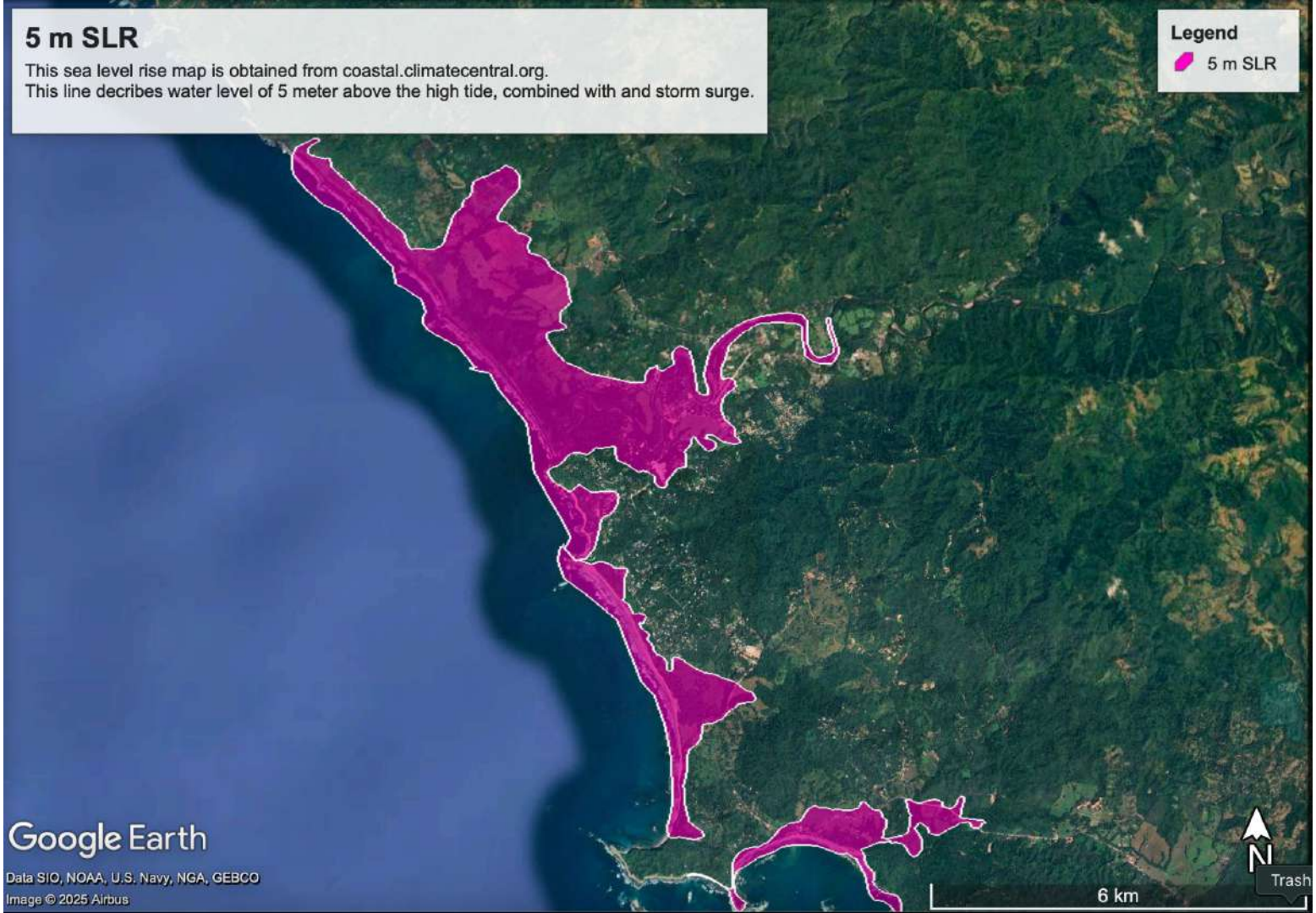
Easier Without a Car

Integrate Communities

Appendix C: Regional Planning | Ecology

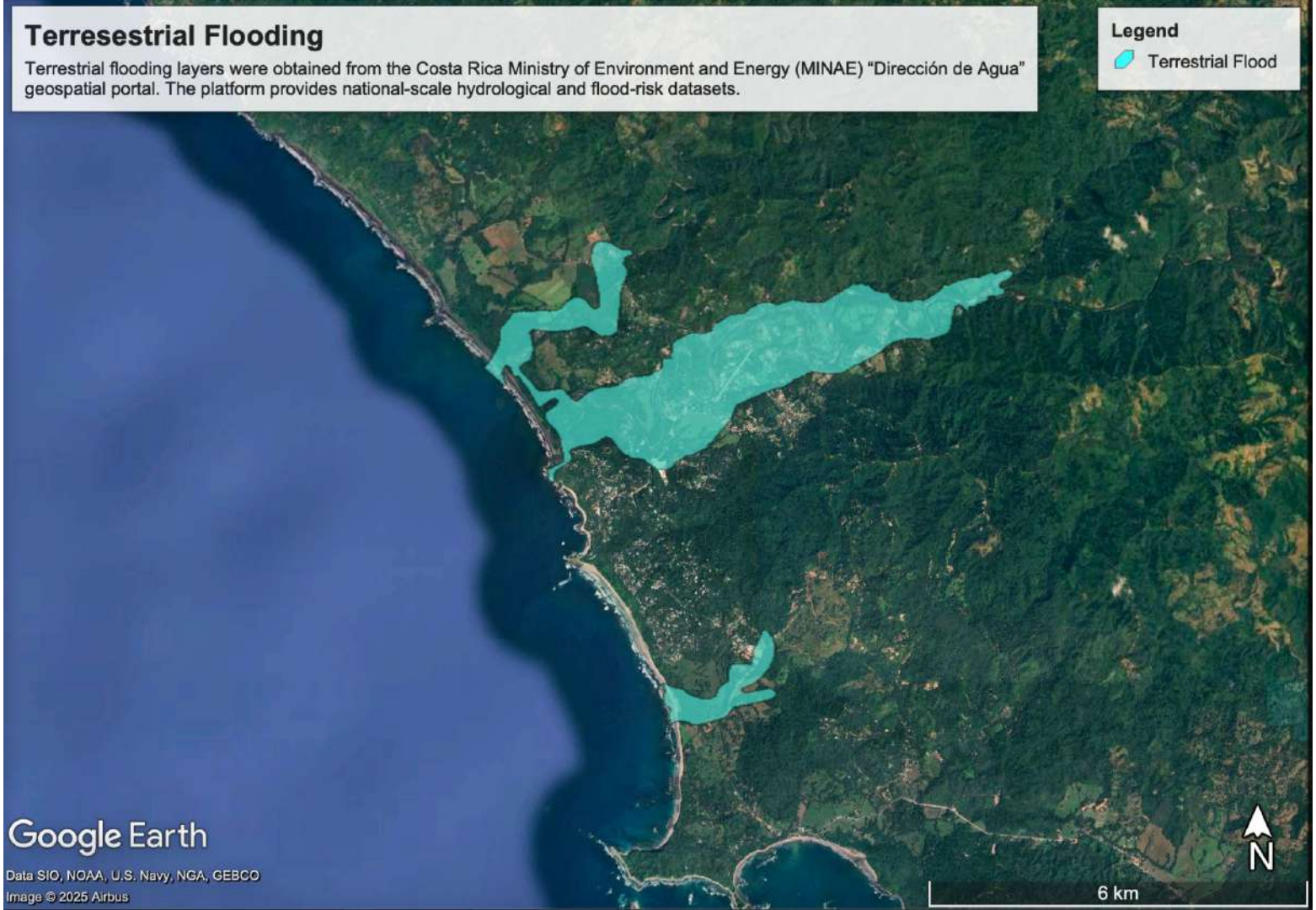

2 m SLR
This sea level rise map is obtained from coastal.climatecentral.org.
This line decribes water level of 2 meter above the high tide, combined with and storm surge.
Legend
2 m SLR
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2025 Airbus
N
6 km

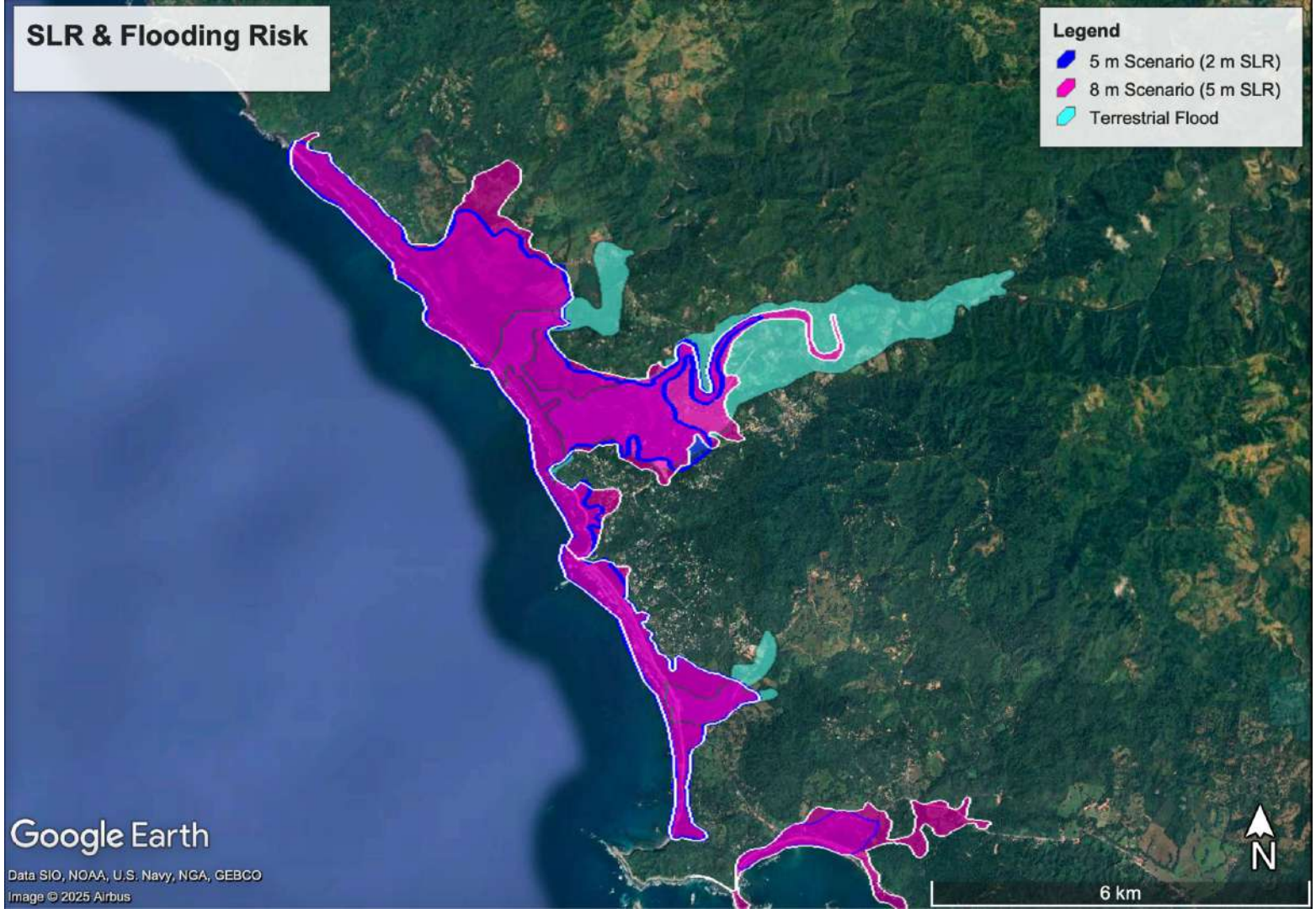

SLR & Flooding Risk
Legend
5 m Scenario (2 m SLR)
8 m Scenario (5 m SLR)
Terrestrial Flood
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2025 Airbus
N
6 km


5 m SLR
This sea level rise map is obtained from coastal.climatecentral.org.
This line decribes water level of 5 meter above the high tide, combined with and storm surge.
Legend
5 m SLR
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2025 Airbus
N
6 km
Trash

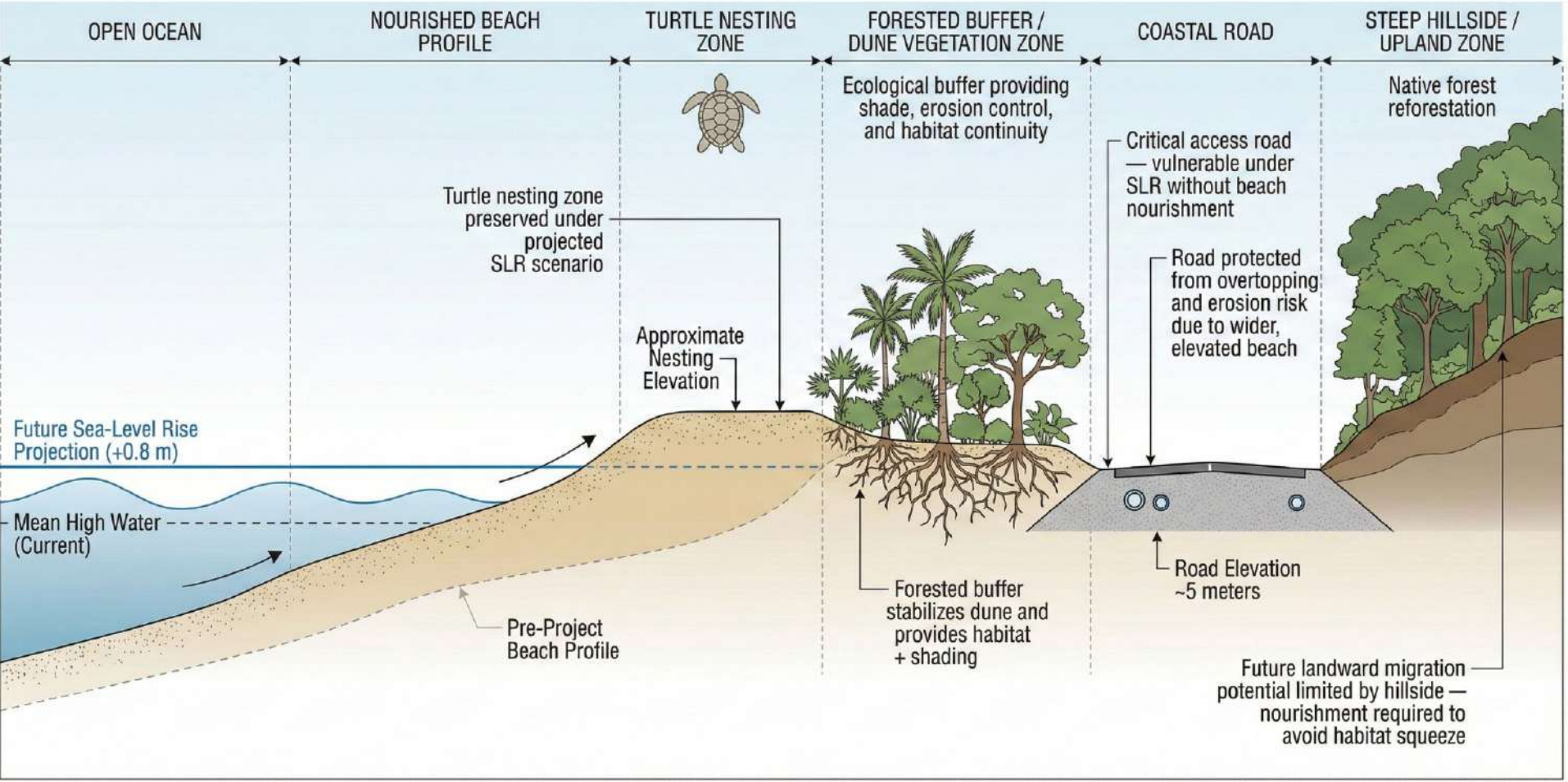
Terresestrial Flooding

Terrestrial flooding layers were obtained from the Costa Rica Ministry of Environment and Energy (MINAE) "Dirección de Agua" geospatial portal. The platform provides national-scale hydrological and flood-risk datasets.

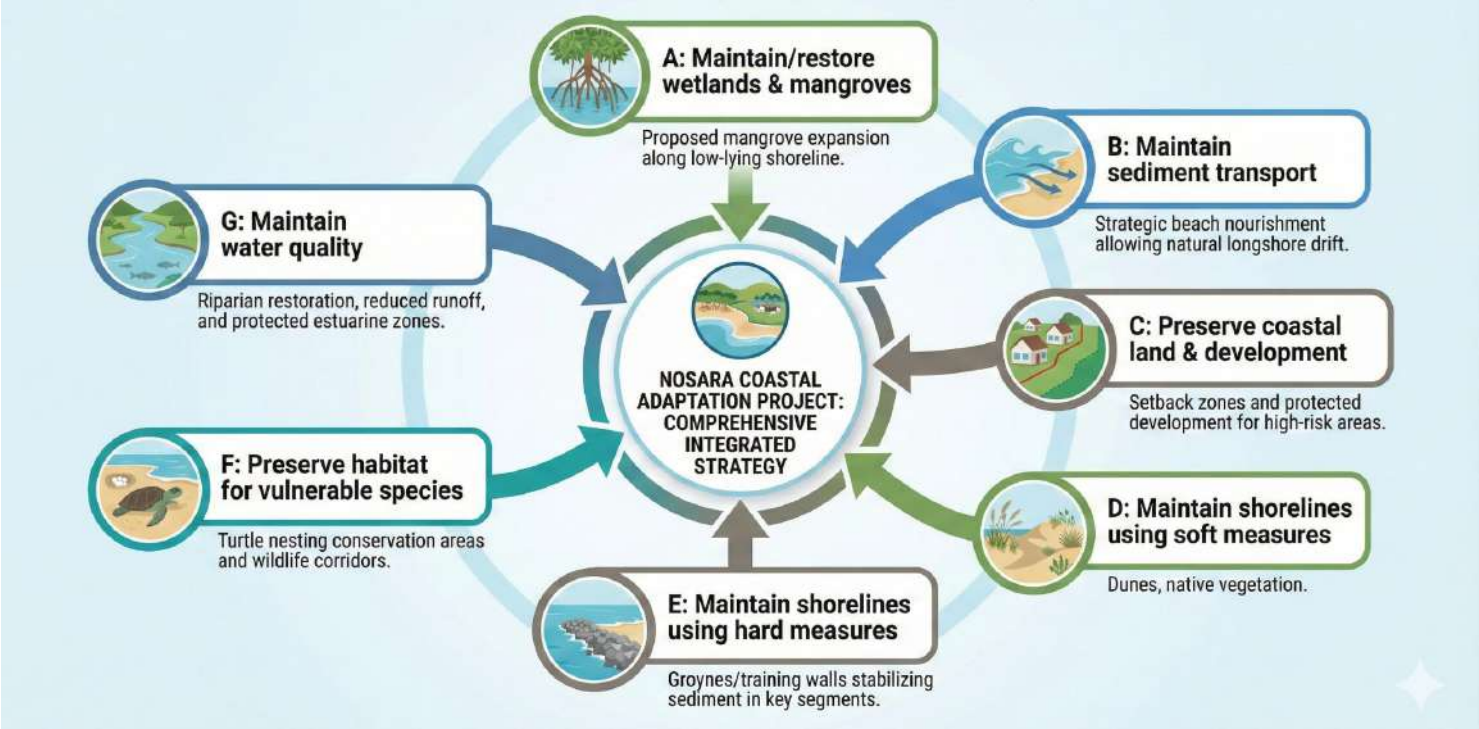



SLR & Flooding Risk
Legend
5 m Scenario (2 m SLR)
8 m Scenario (5 m SLR)
Terrestrial Flood
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2025 Airbus
N
6 km

CROSS-SECTION: BEACH NOURISHMENT & ECOLOGICAL BUFFER - OSTIONAL, COSTA RICA



Nosara Shoreline Adaptation Strategies



Sabías que?...

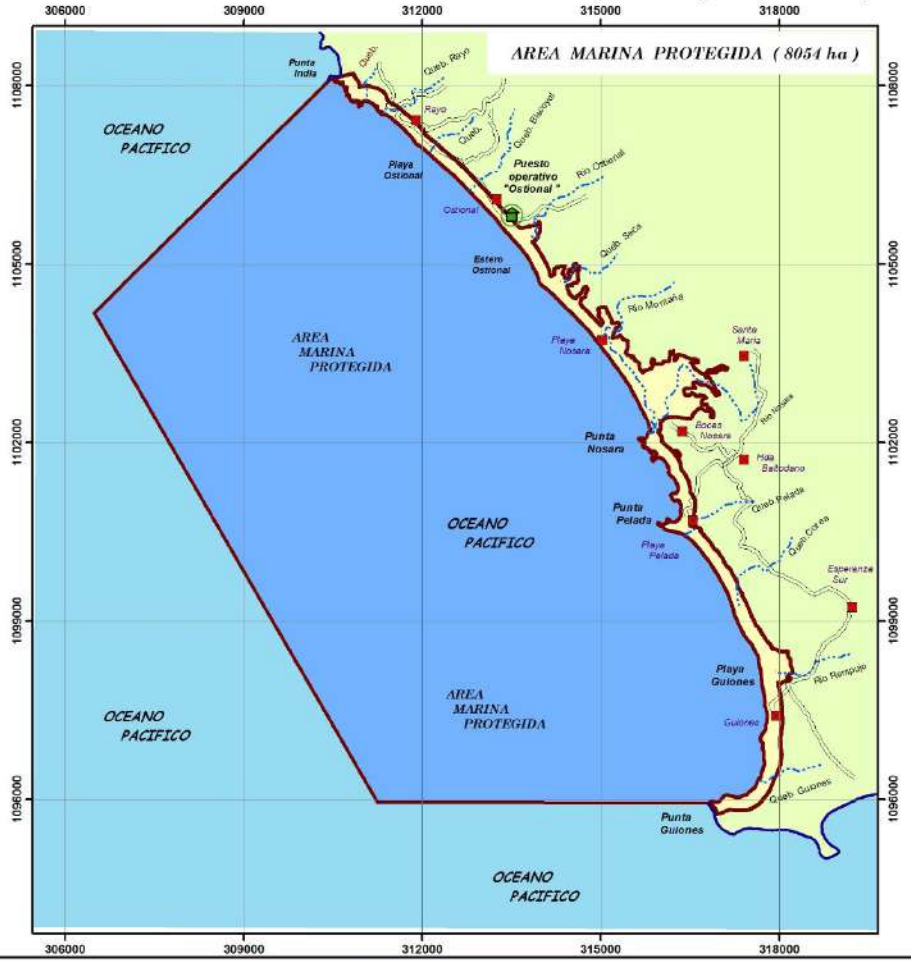
Corredor Biológico Río Nosara

_Tiene una área de 418,8km2 y sus aguas desembocan en el Océano Pacífico. Tiene un perímetro de 125,6 kilómetros y es un sistema hidrográfico compuesto por tres subcuencas: Nosara, Montaña y Quebrada Seca.

Político-administrativamente esta cuenca pertenece a los municipios de Nicoya, Santa Cruz y Hojancha, en la provincia de Guanacaste. (Hernández,2010)

Referencia info: Hernández-Ulate, A. (2011). Capacidad del uso de la tierra y los cambios en la cuenca del río Nosara, Guanacaste, 1979 - 2006. *Revista Tecnología En Marcha*, *23*(3), pág. 3. Recuperado a partir de https://revistas.tec.ac.cr/index.php/tec_marcha/article/view/68

REFUGIO DE VIDA SILVESTRE OSTIONAL (MIXTO) --- (510 ha)



MINISTERIO DEL AMBIENTE Y ENERGIA
SISTEMA NACIONAL DE AREAS DE CONSERVACION
DPTO. DE INFORMACION Y REGULARIZACION TERRITORIAL

AREA DE CONSERVACION TEMPISQUE

SIMBOLOGIA :

- CENTROS POBLADOS
- PUESTO OPERATIVO DEL SINAC
- CARRETERAS Y CAMINOS
- RIOS Y QUEBRADAS
- LIMITE DEL REFUGIO DE VIDA SILVESTRE OSTIONAL (MIXTO)

DECRETO EJECUTIVO O LEY QUE RIGE ESTA AREA SILVESTRE PROTEGIDA : **LEY # 6919 DEL 17-11-1983**

ELABORADO POR : **GUILLERMO JIMENEZ B**

FECHA DE ELABORACION : **ABRIL , 2018**

ESCALA DE IMPRESION : **1 : 65.000**

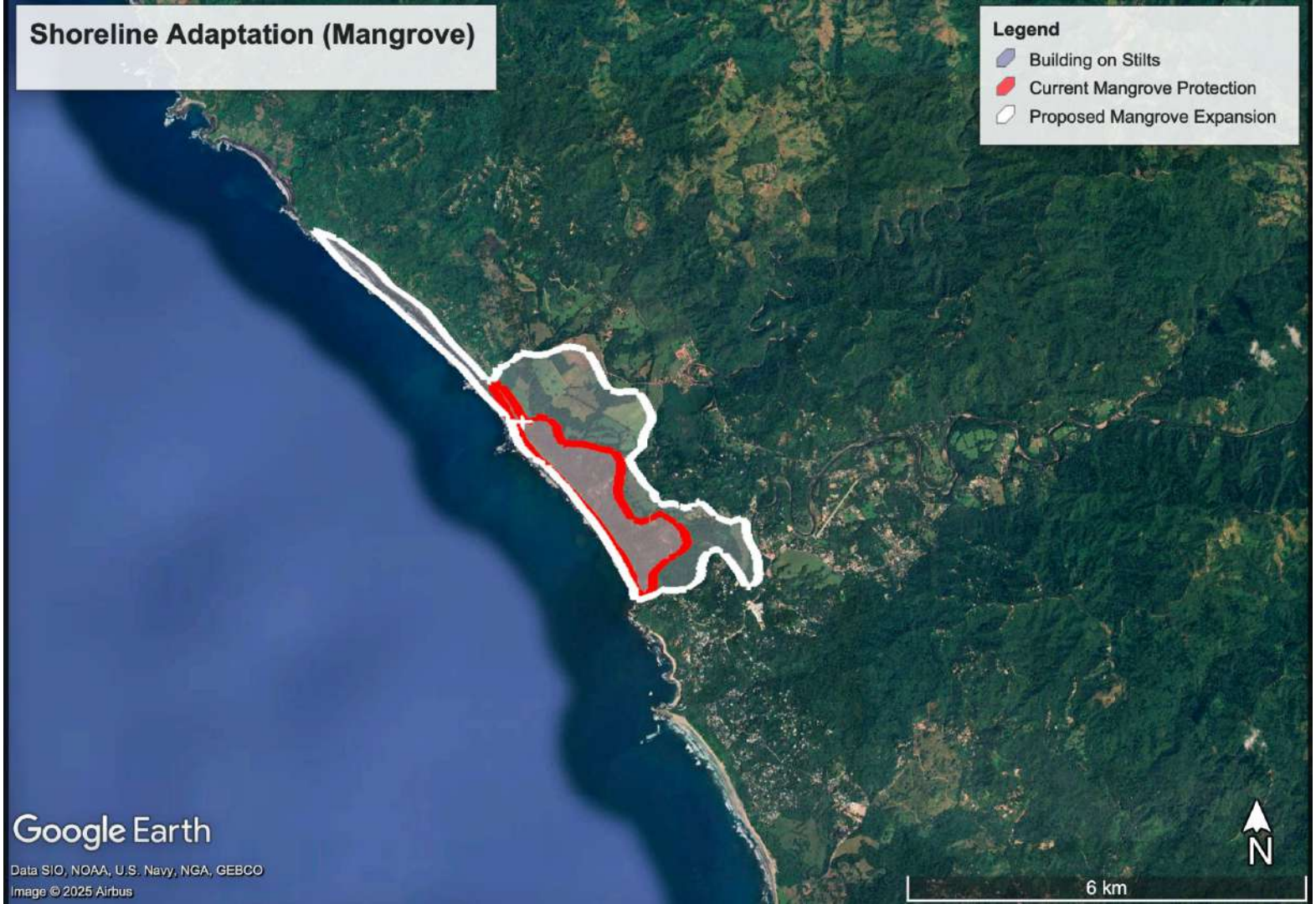
PROYECCION TRANSVERSAL DE MERCATOR PARA COSTA RICA (CRTM05)
DATUM WGS84 --- ELIPSOIDE WGS84

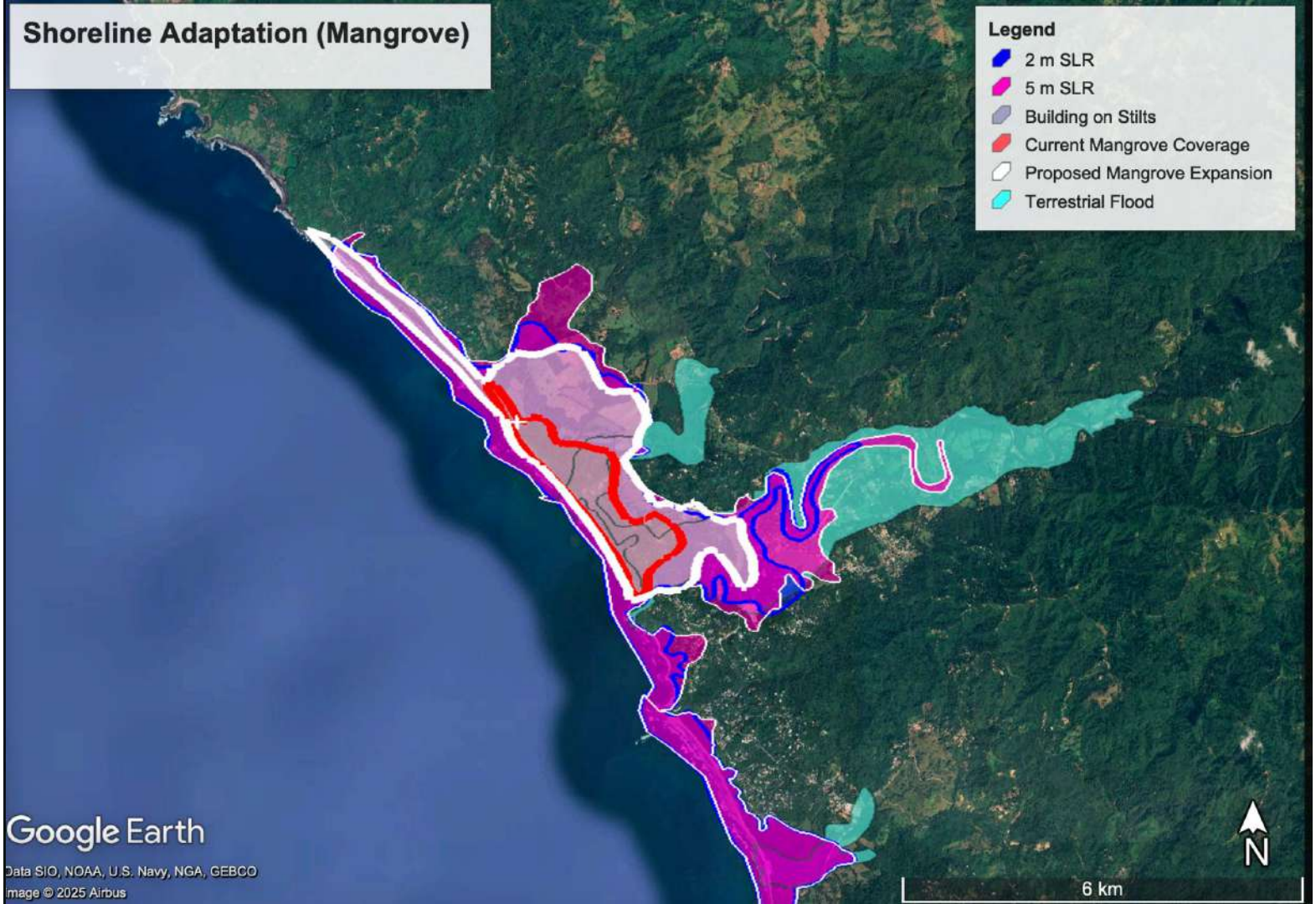
1 0.5 0 1 2 3 4 Kilometros

ESCALA GRAFICA

CODIGO DEL SINAC PARA ESTA AREA SILVESTRE PROTEGIDA : **V06**

MAPA : **1**


Shoreline Adaptation (Mangrove)
Legend
Building on Stilts
Current Mangrove Protection
Proposed Mangrove Expansion
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2025 Airbus
N
6 km


Shoreline Adaptation (Mangrove)
Legend
2 m SLR
5 m SLR
Building on Stilts
Current Mangrove Coverage
Proposed Mangrove Expansion
Terrestrial Flood
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2025 Airbus
N
6 km

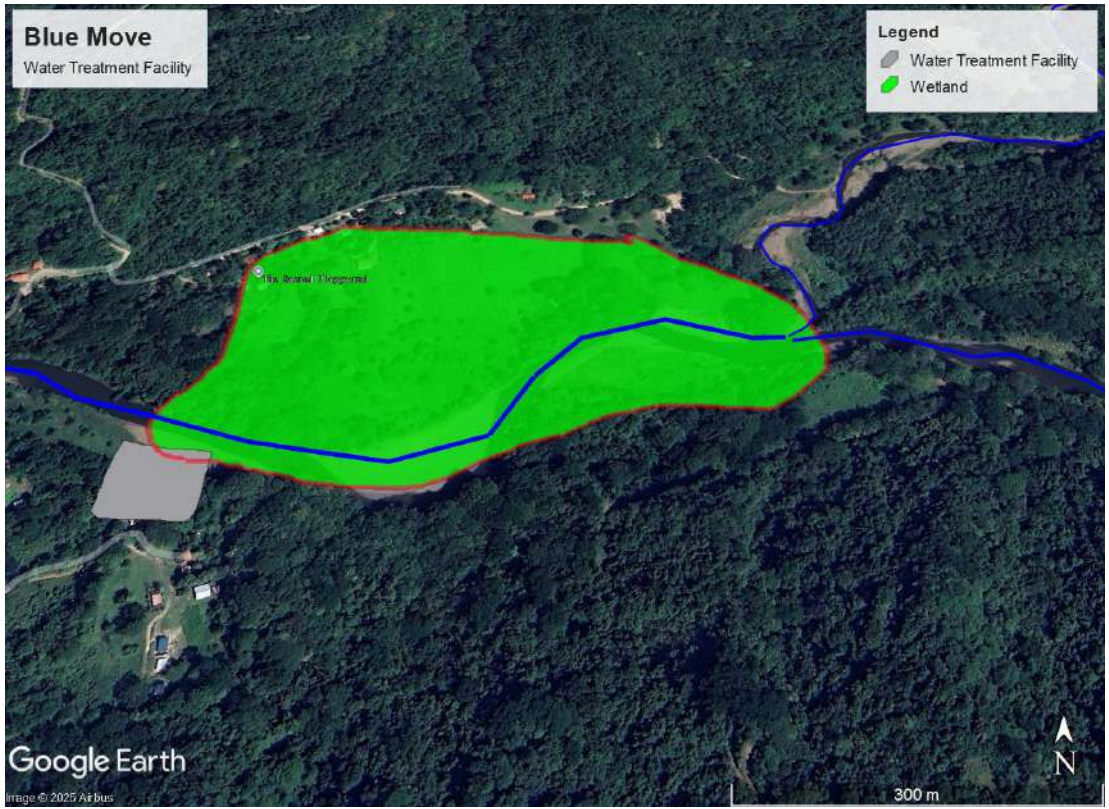
Appendix D: Regional Planning | Big Moves

Regional Planning | Big Green/Blue Moves

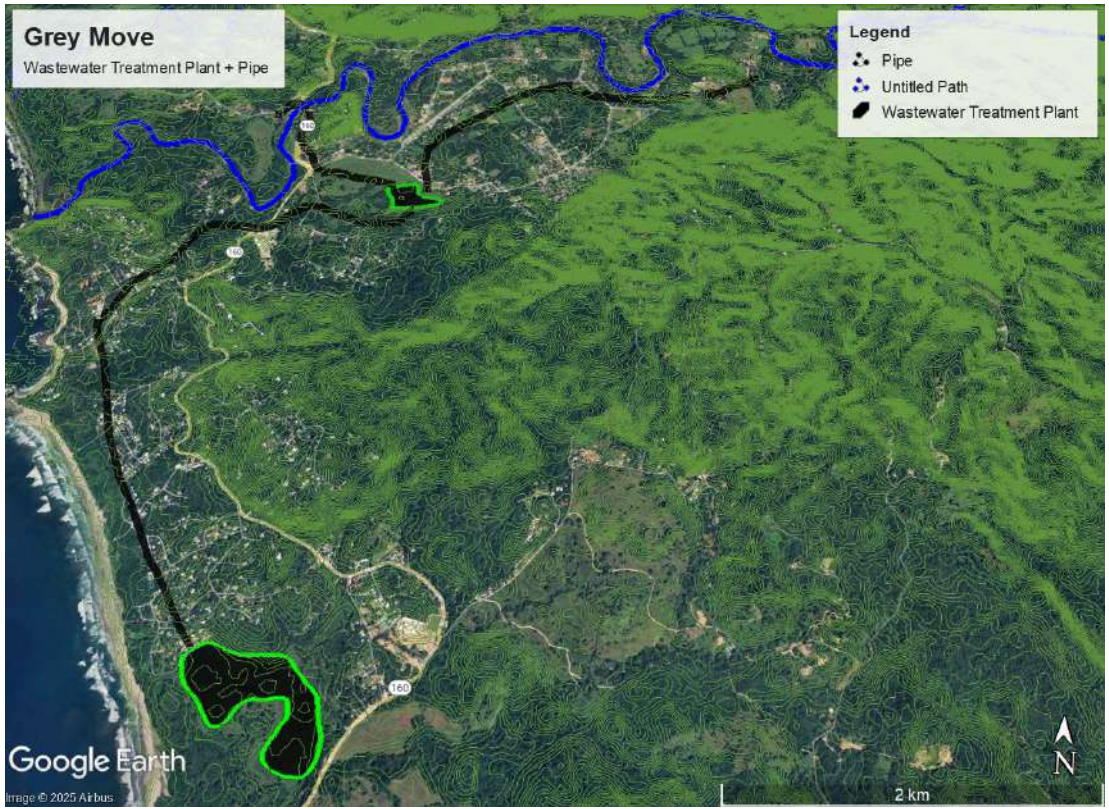
- Green
  - Riparian corridors + Levee
  - Wetland
  - Floodplain Parks
  - Reforestation of upstream watershed
- Blue
  - Water Retention Pond
  - Water Treatment Facility
- Grey
  - Wastewater treatment

Blue - Water Treatment Facility

Purpose: Further treats water coming from upstream after the wetland, might be a small scale. Input and output to the river at the same pace.



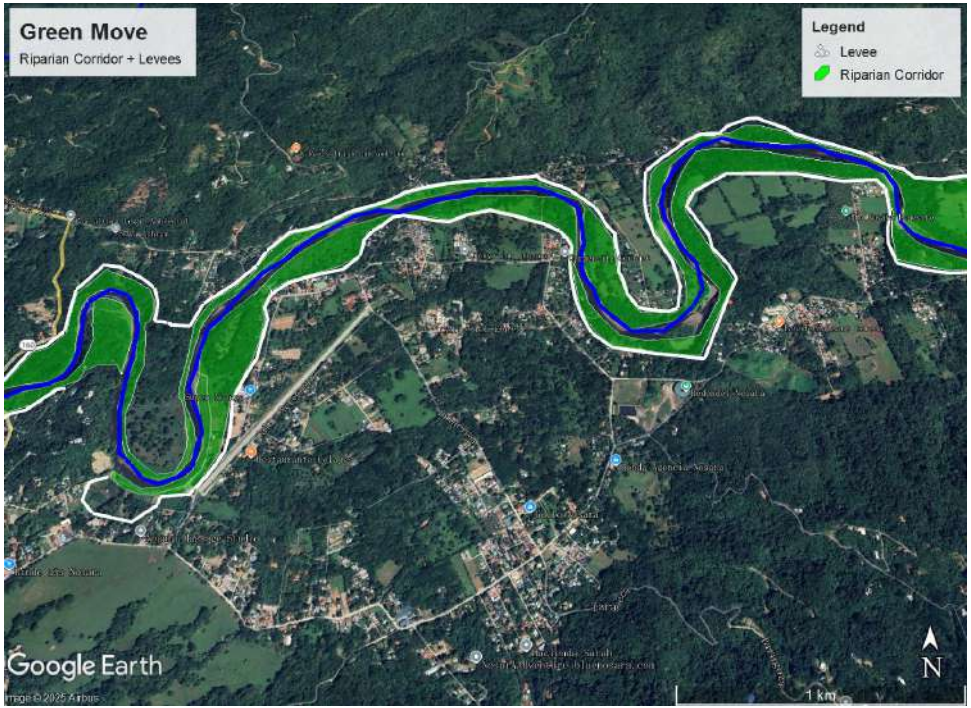
Grey - Wastewater Treatment Plant + Pipe



Situated in a flat, flood-safe area outside hazard zones.

Purpose: Centralized plant or plants treating regional wastewater for underground groundwater recharge.

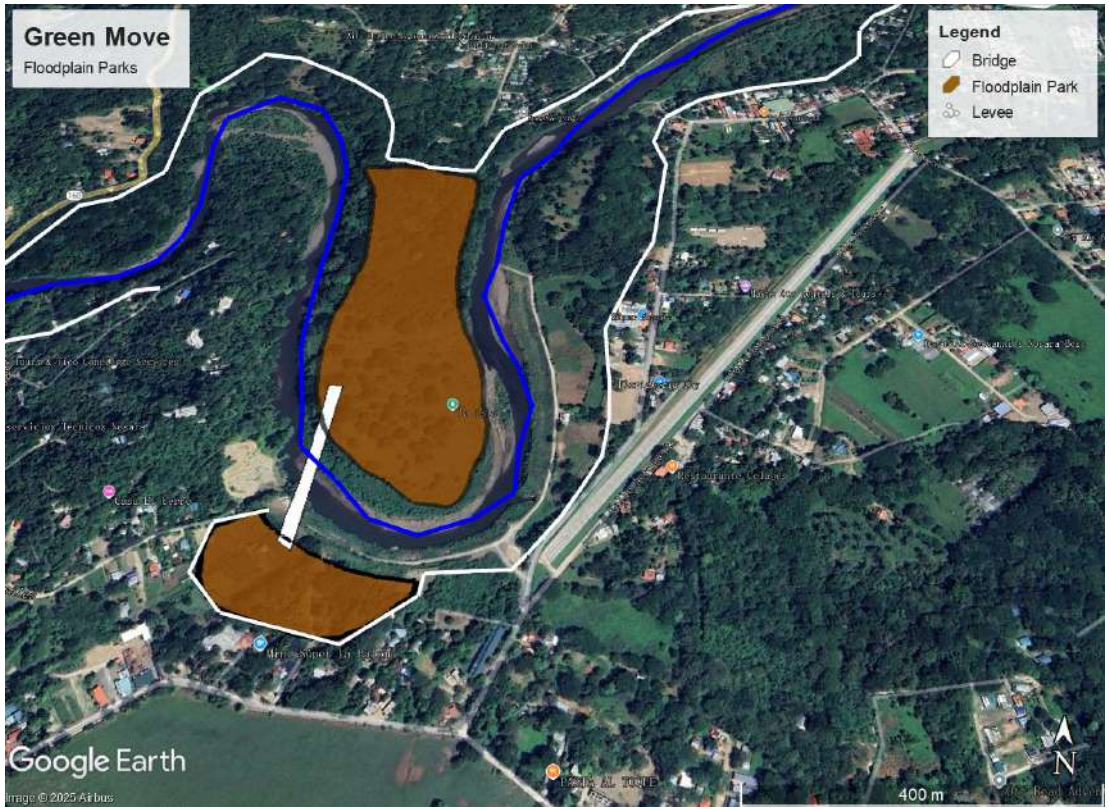
Green - Riparian Corridors + Levees



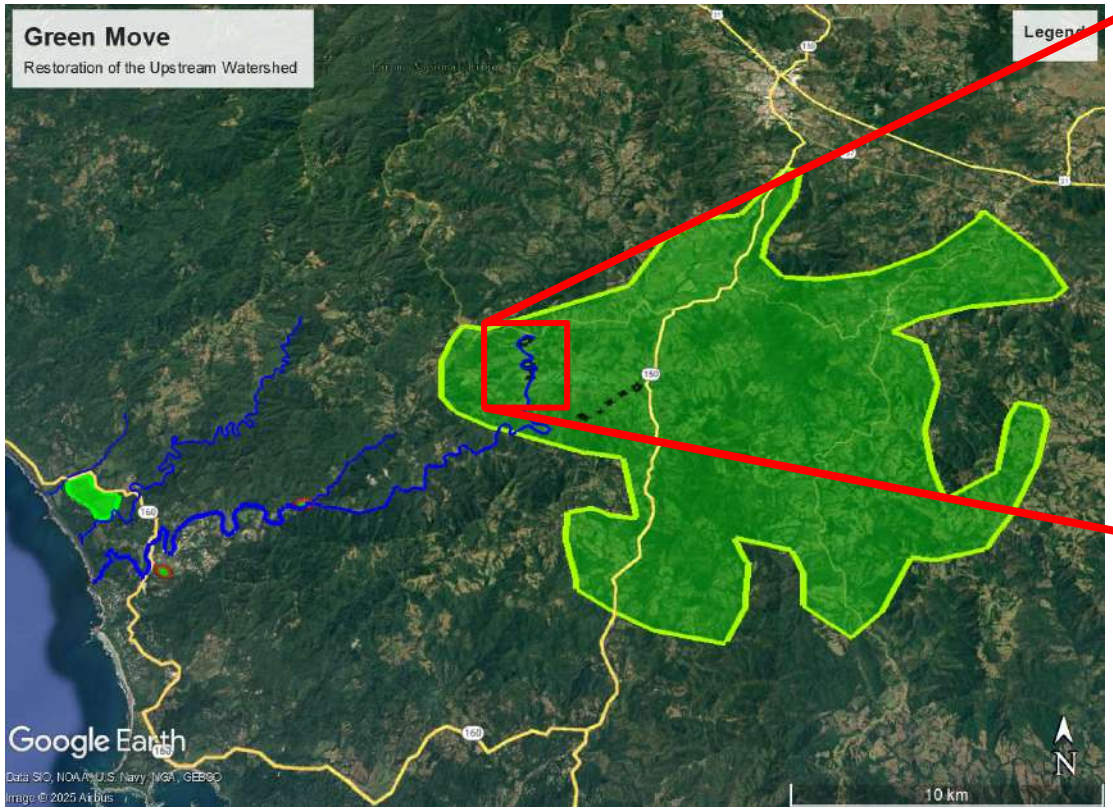
Purpose: Takes on extra water when river level rises, and cleans more sediments from the river. And Green levees that mitigates and prevents river flooding

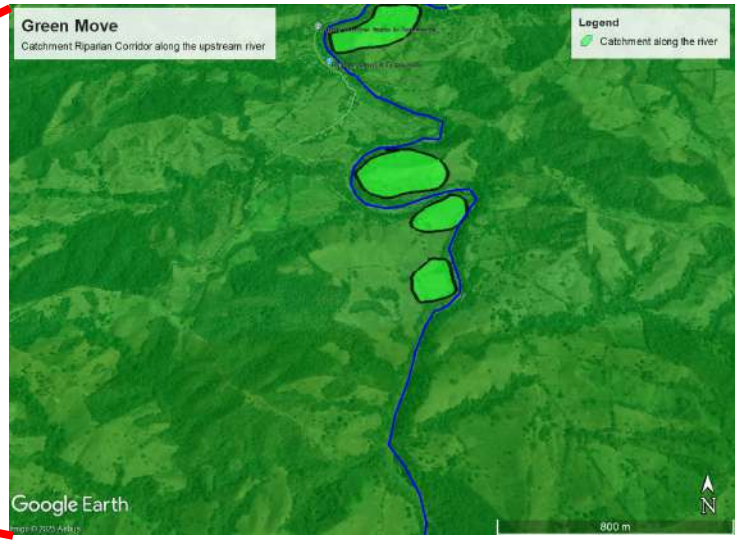
Green - Floodplain Parks

Purpose: Entertainment, leisure-time hangout, and artificial detention pond that holds seasonal flooding



Green - Restoration of the Upstream Watershed



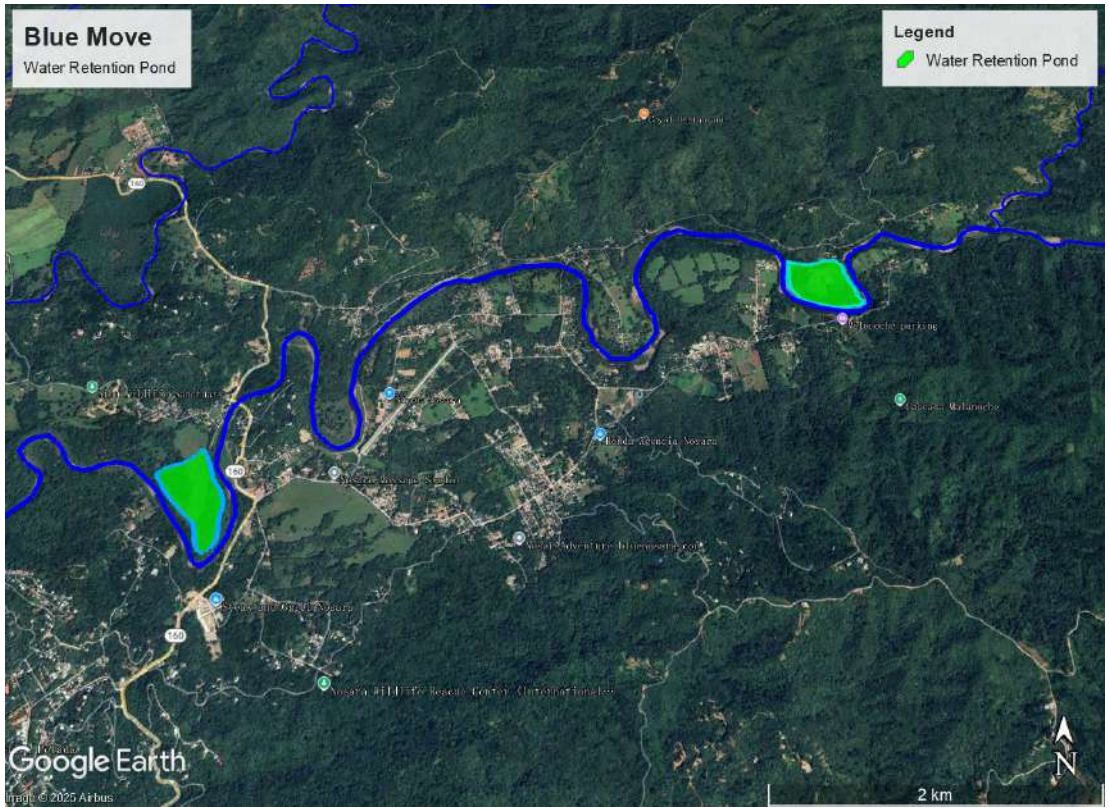


Catchment Riparian Corridor along the upstream river

Purpose: Built along the river, serves as wetland/corridors that takes on river water, cleaning the sediments and slowing down the river water speed.

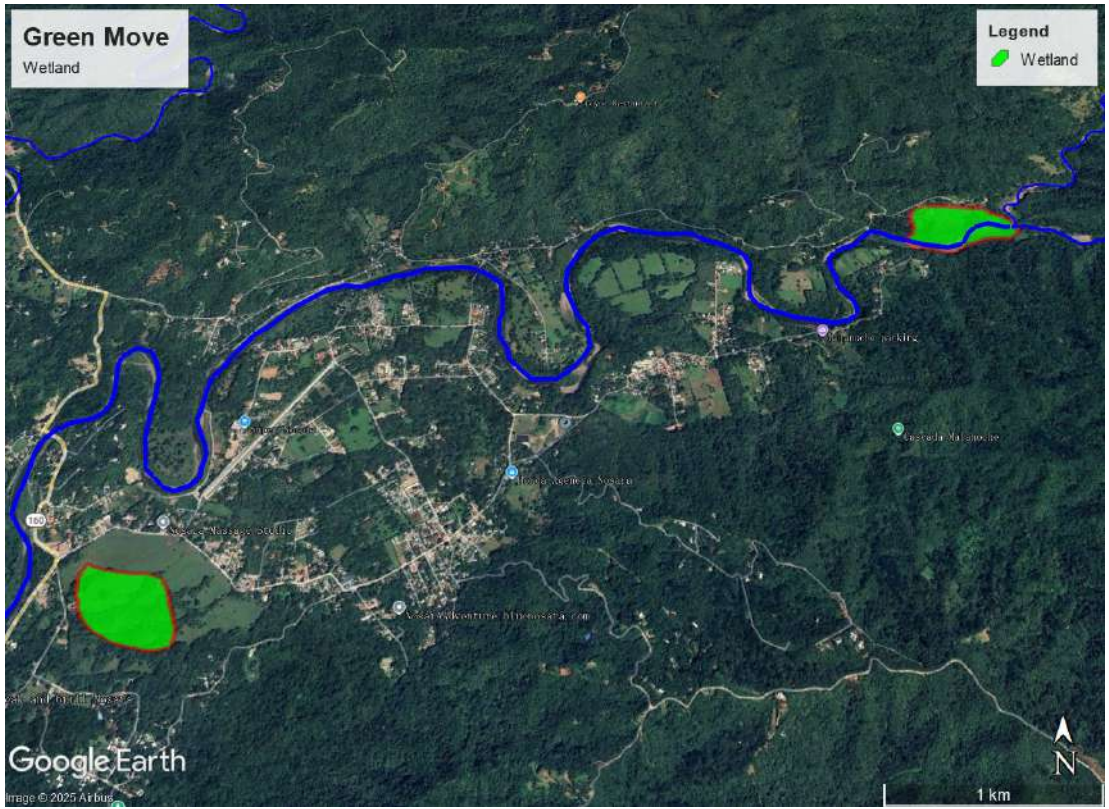
Blue - Water Retention Pond

Purpose: Collects Stormwater, takes on extra river water when needed.



Green - Wetland

Purpose: Cleaning water from upstream and collect sediments



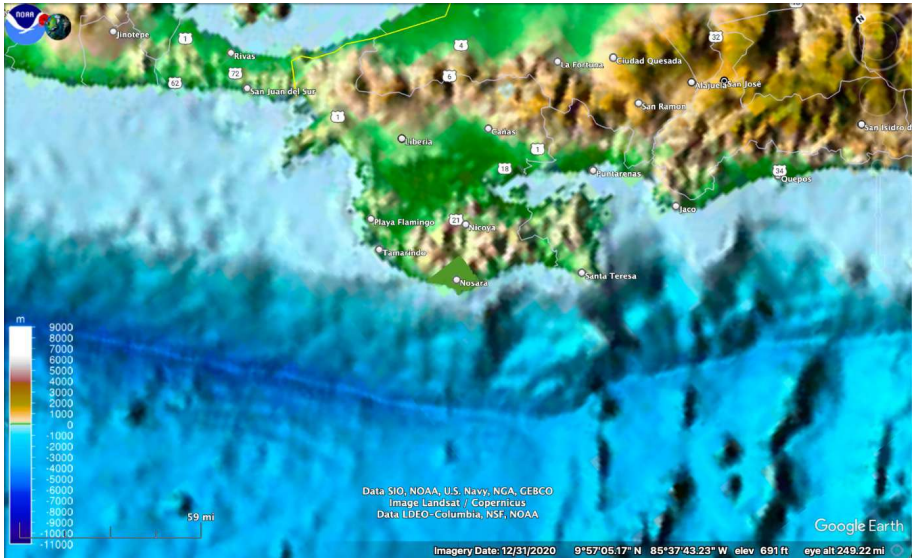
Appendix: Levee Considerations

Item	Value	Notes (short)
Overbuild allowance	0.2 m	Extra height added during construction so final levee remains correct after settlement.
Freeboard	0.5 m	Uncertainty margin
Side slope (both sides)	2.2H : 1V	Slope 3:1 to 2:1
Crest width	8 m	Trail + safety
Slope footprint each side	≈ 10 m	5 m height × 2H
Total levee width	≈ 30 m	10 m + 6 m + 10 m
Location setback	Varies	Space for floodplain/sediment

Appendix: Beach Nourishment

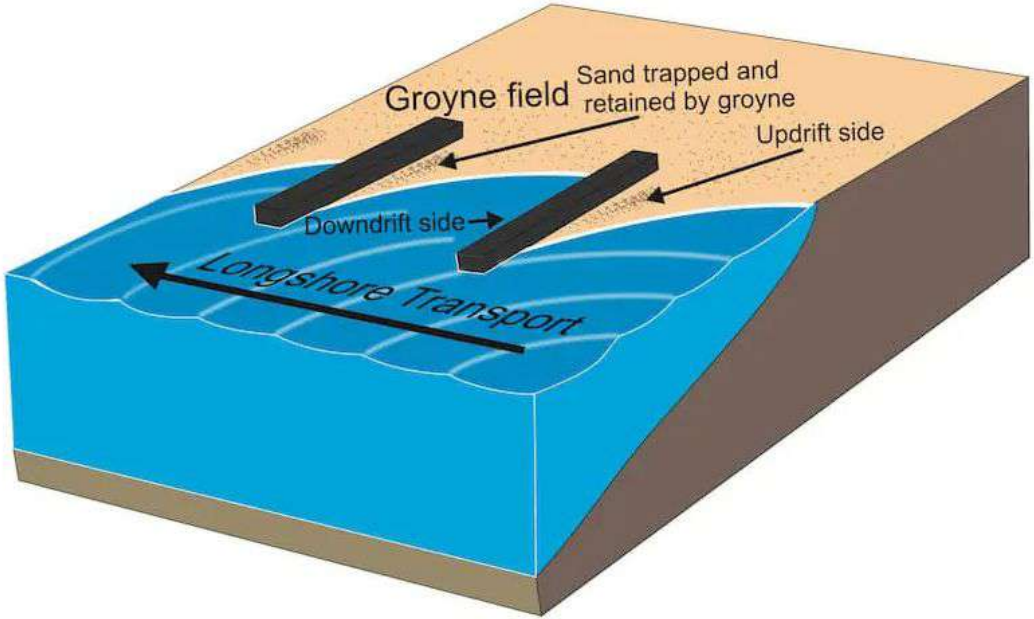
Category	Playa Nosara	Playa Guiones	Playa Ostional
Turtle Sensitivity	Low–moderate	Moderate	Very high (arribada)
Primary Sand Source	Offshore borrow	Offshore borrow	Nearshore/offshore with strict testing
Secondary Sand Source	River mouth (shoaling only)	Internal sand recycling	Offshore dredging with similar sands within Nosara (limited, only after testing)
Sand Compatibility Needs	Medium	Medium	Very high (grain size, mineralogy, biology)
Construction Timing	Avoid turtle season	Avoid turtle season	Avoid arribadas & peak nesting
Frequency	3-5 years	3-5 years	5-7 years
Placement Method Notes	Standard bulldozing	Standard + sand recycling	Gentle lifts, till sand, heavy monitoring
Risks to Manage	Turbidity	Scarp formation	Nest burial, compaction, heat changes, microbes

https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2021.814589



Offshore sand resources for potential dredging are identified on the inner shelf at depths up to approximately 50-60 m. The study notes that deposits are considered only where water depth is sufficiently shallow for dredging. However, sand & sediment characteristics are needed to be done locally & extensively.

https://www.iadc-dredging.com/wp-content/uploads/2017/02/article-assessment-of-offshore-sand-and-gravel-for-dredging-64-3.pdf



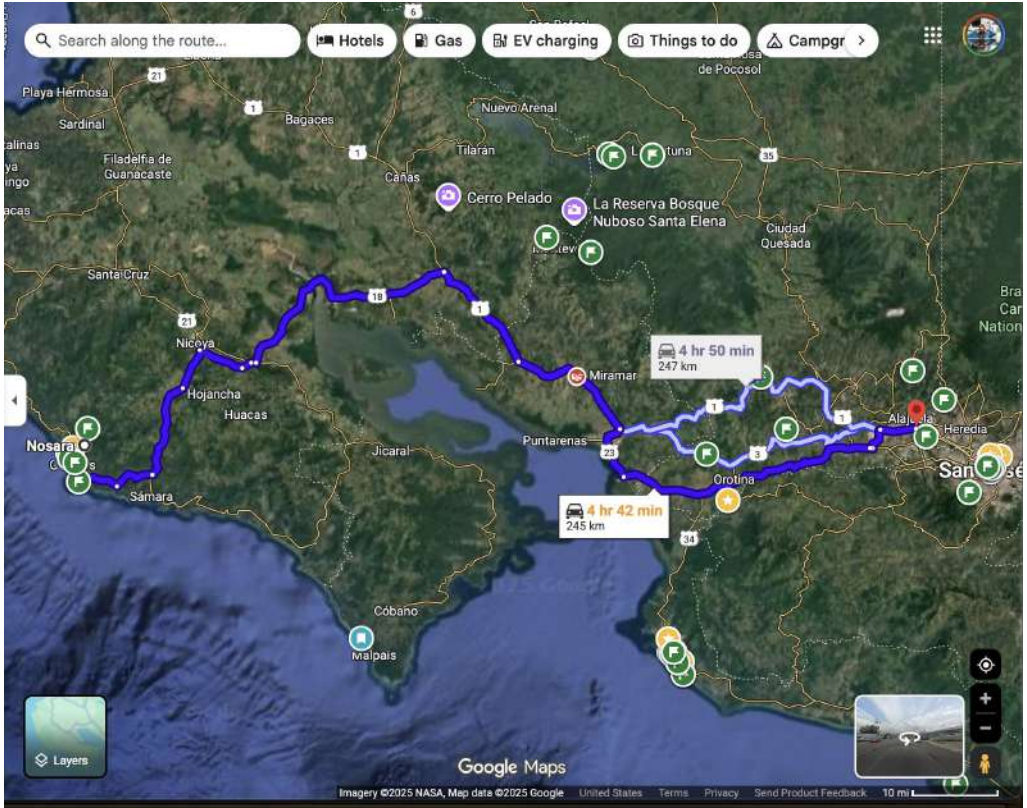
Groynes traps sands and retained sands it reduces the risk of losing the beach.

https://www.iasgyan.in/daily-current-affairs/groynes

Appendix E: Regional Planning | Housing

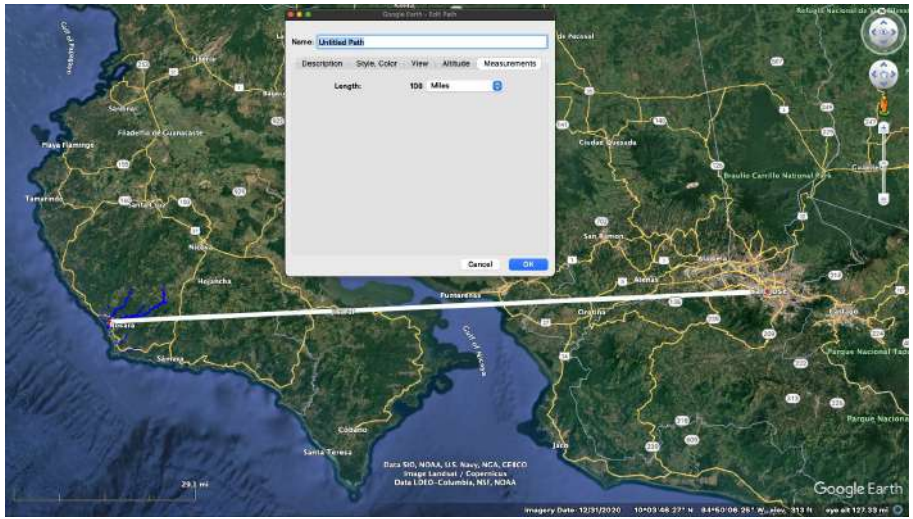
Appendix F: Regional Planning | Transportation

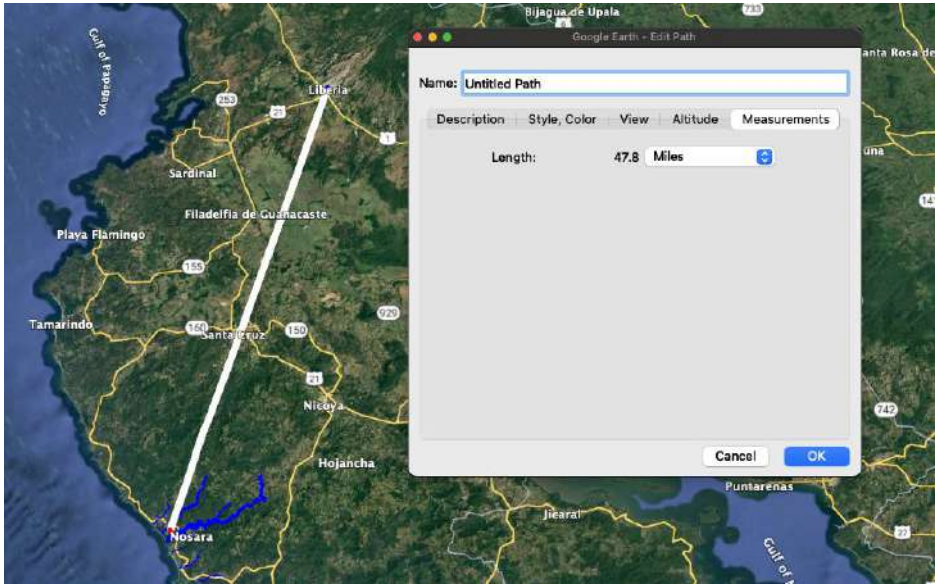
Driving Distance: Nosara to San Jose Airport



EVTOL Distance

Left: (San Jose - 108 miles)
Right: (Liberia - 48 miles)





Appendix G: Regional Planning | Utilities

Economic Moves

Goals

- Equitable growth
- DIversify Economy
- Reduce seasonality
- Reinvest in Nosara

- Ecology
- Adventure Tourism
- Blue-Zone Tourism
- Real Estate Tax
- Education
- Remote Work Economy

- Marine Biological Institute
- ESA - pay for land preservation
- Adventure Tourism
- Tourism fees - Tourism Impact Contribution (TIC)
- Transportation fees
- Connect the top of the valley to the beach
- Energy abundance
- NGO partnerships - ecological preservation & resea
- Job training programs
- Organic/Regenerative Agriculture Programs
- Blue Zone Tourism
- Real Estate Tax
- Seed fund local entrepreneurship

Policy Recommendations

WATER

- Modernize water & wassewast treatment
- Watershad management authority

ECOLOGY

- Protect coastal & nature zones
- Low-impact development (LID) requirements

MOBILITY

- Limit car ownnship; clean mobility
- Mobility hiearricy

LAND USE

- Transfer of Development Rights
- Tourism impact fees

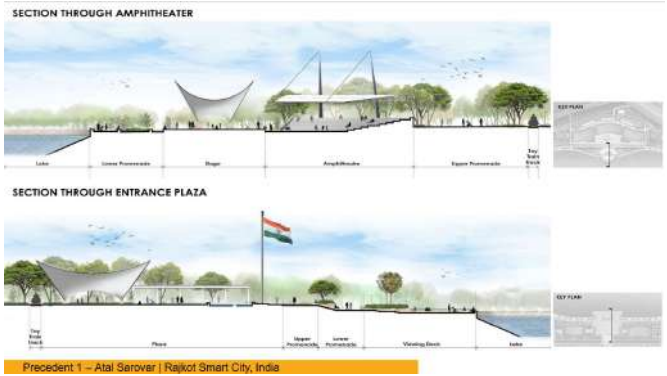
COMMUNITY

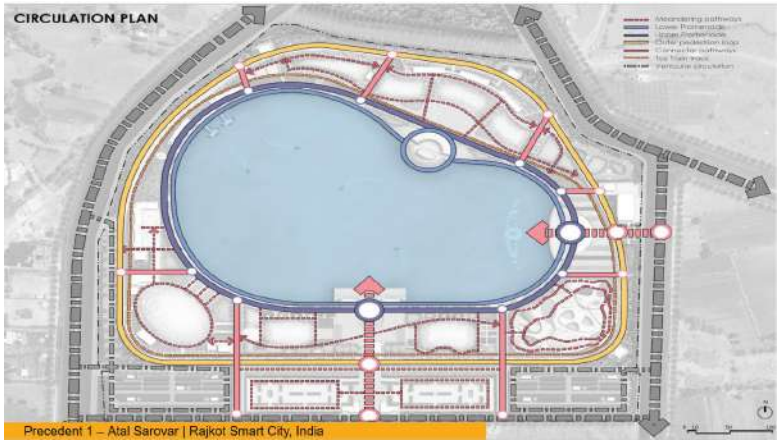
- Local employment & training
- Affordable housing

Appendix H: Site Scale Plans (i think these are integrated into other slides)

Appendix I: Precedent Projects

Atal Sarovar | India (Retention Lake Precedent)





- *Engineered channels + public edges*
- *Seasonal stormwater capture*
- *Year-round water level via natural treatment*

Key adoption

- Our **retention ponds** → become **community waterfronts**
- Paths + gardens around hydrology → **social + ecological function**
- Combination of **engineered drainage** with **wetland treatment**

Bishan–Ang Mo Kio Park | Singapore (Floodable Park Precedent)

Key strategies

- Naturalized river channel & riparian restoration
- Soft banks designed to *expand* during floods
- Community access even in flood season

In Nosara

- **Floodplain park** integrates mobility + shade
- **Multi-season use** → daily life in dry conditions, safe expansion in wet conditions

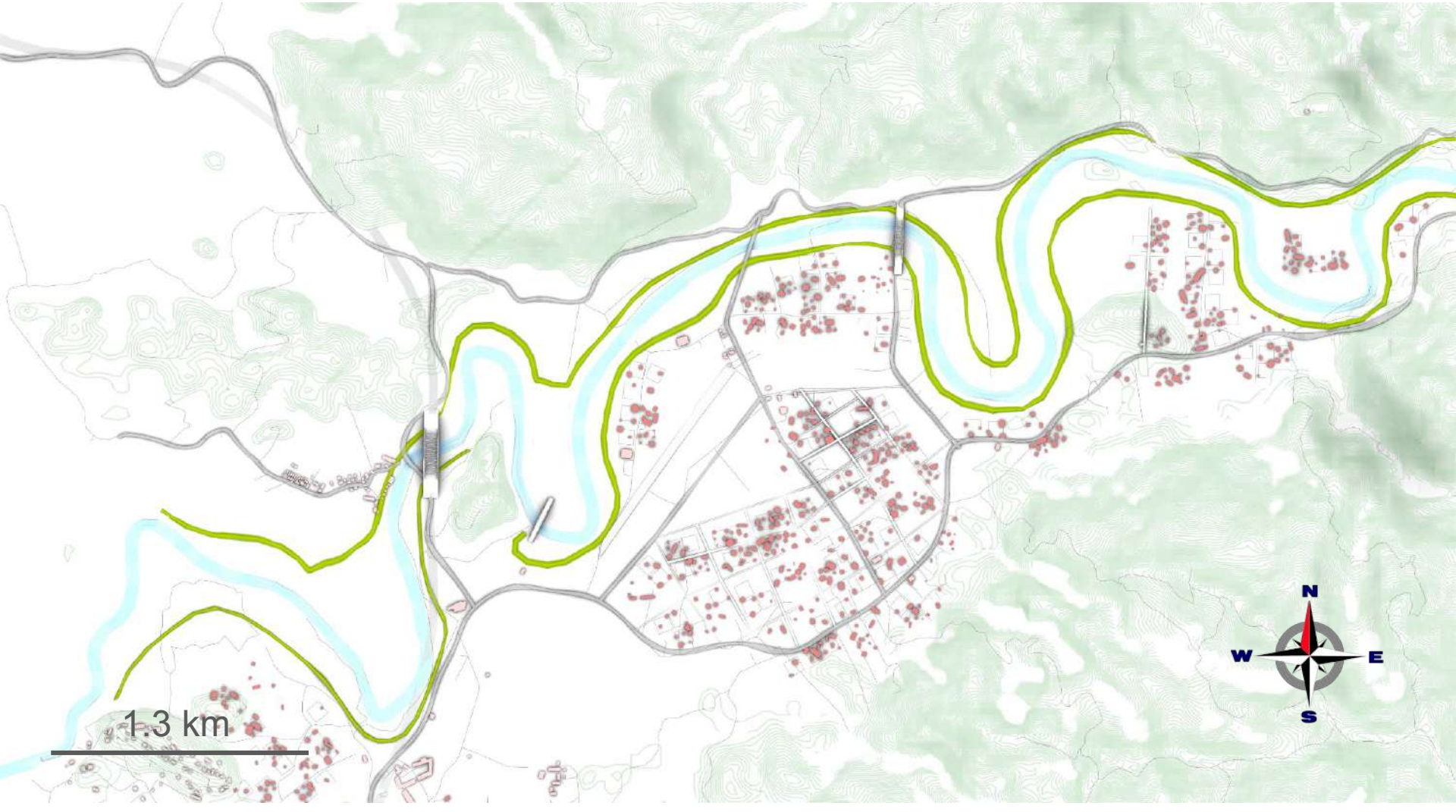
Yanweizhou Park | China (Wetland & Connectivity Precedent)

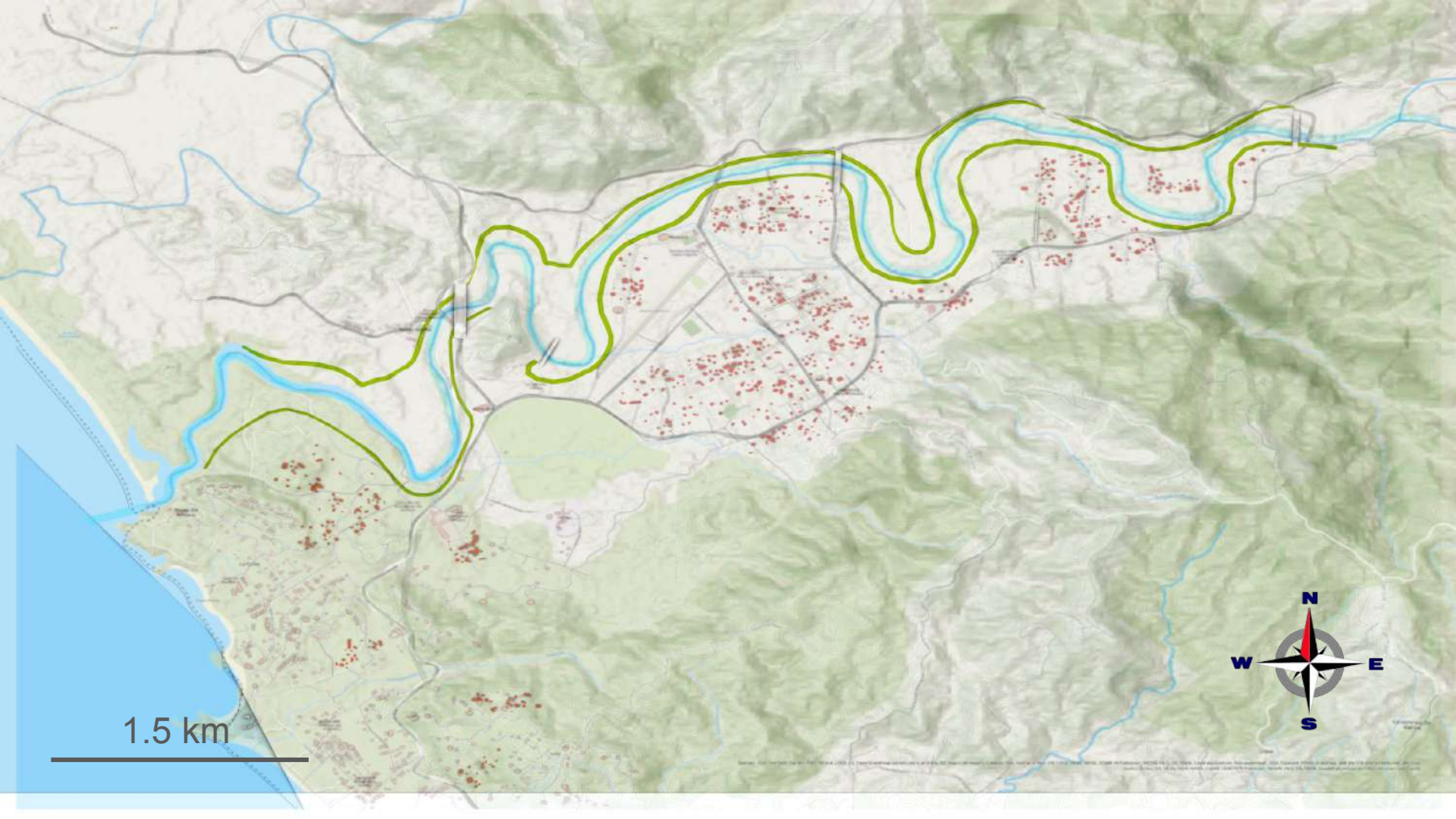
Key strategies

- **High bridge** → access preserved during 200-yr flood
- **Terraced wetland edges** → designed for submersion
- **Flood-adaptive planting** → regrows stronger after floods
- **Bioswale & infiltration ponds** → reduce erosion + treat runoff

What we borrow

- **Elevated mobility spine** between neighborhoods
- **Submersible parkland** for seasonal flooding
- **Constructed wetlands** for filtration + ecology


1.3 km
N
W
E
S


N
W
E
S
1.5 km

Appendix J: Energy

Electricity Needs Calculation (Non-Mobility)

Item	Assumption / Input Value	Remarks
National electricity use (Costa Rica)	2,529 kWh/person/year	Used to estimate baseline community electricity demand before EVs
Community population (Doubled Population)	14,000 residents	Planning estimate for full masterplan scenario
Solar PV yield (Nosara)	1,530 kWh/kWp/year	Typical annual production per unit installed PV capacity
EV modeling components	Electric buses + e-bikes (explicit energy modeling)	Cars can be added, but main model uses buses + e-bikes
Urban block structure	200 blocks	Used to estimate available rooftop area
Rooftop PV potential	Derived from 200 blocks	Determines number of PV-capable blocks for system sizing
Model refinement note	Building EUIs not finalized	All values are *preliminary* and will be updated with detailed building models

Electricity Needs Calculation

Description	Input / Assumption	Calculation	Result	Remarks
Baseline non-EV electricity demand	35,406,000 kWh/year	—	**35,406,000 kWh/year**	2,529×14,000=35,406,000 kWh/year
20% overhead	20% (0.20)	0.20 × 35,406,000	**7,081,200 kWh/year**	Accounts for future growth + uncertainty
Add overhead to baseline	Baseline + overhead	35,406,000 + 7,081,200	**42,487,200 kWh/year**	Adjusted annual demand
Convert to GWh	÷ 1,000,000	42,487,200 ÷ 1,000,000	**42.49 GWh/year**	Converted for planning-level reporting
Planning rounded value	—	—	**≈ 42.5 GWh/year**	Final value used for PV + battery sizing

Electricity Needs Calculation

Item	Assumption / Input	Calculation	Result	Remarks
Annual non-mobility demand	42.5 GWh/year (with 20% overhead)	42.5 GWh × 1,000,000 = 42,500,000 kWh	42,500,000 kWh/year	Includes future growth + lifestyle uncertainty
PV yield	1,530 kWh/kWp/year (Nosara)	-	1,530 kWh/kWp/yr	Annual yield for good solar resource from PV yield map
Required PV capacity (kWp)	Demand ÷ PV yield	42,500,000 kWh ÷ 1,530 kWh/kWp	27,777 kWp	Exact value before rounding
Required PV capacity (MWp)	kWp → MWp	27,777 kWp ÷ 1,000	≈ 27.8 MWp	Used as main design value

Solar Rooftop Needs Calculation

Item	Assumption / Input	Calculation	Result	Remarks
Panel power density	0.2 kWp/m² (200 Wp/m²)	-	**0.2 kWp/m²**	Typical for modern PV modules
Panel area needed	Capacity ÷ density	27,777 kWp ÷ 0.2 kWp/m²	**≈ 138,900 m²**	*Actual PV panel area*, not total roof
Roof coverage factor	Only 50% of roof can host panels	-	**50% coverage**	Accounts for setbacks, walkways, shading, etc.
PV-capable rooftop area	Panel area ÷ coverage factor	138,900 m² ÷ 0.5	**≈ 277,800 m²**	Total roof area that must be covered by PV

Critical Load Calculation for Batteries

Item	Assumption / Input	Calculation	Result	Remarks
Annual non-mobility demand	42.5 GWh/year	42.5 GWh ÷ 365	0.1164 GWh/day	Average daily energy
Daily demand in MWh	GWh → MWh	0.1164 × 1,000	≈ 116.4 MWh/day	Used for storage sizing
Critical load fraction	50% of total	0.5 × 116.4 MWh	≈ 58.2 MWh/day	Only essential services (fridges, water, clinics, etc.), assume backup 50%

Battery Storage & Second-Life EV Packs

Item	Assumption / Input	Calculation	Result	Remarks
Target storage	One full day of critical load	-	**≈ 58.2 MWh**	Planning range: **55–60 MWh**
EV pack usable capacity	60 kWh original, 70% usable	60 kWh × 0.7	**42 kWh per pack**	Second-life EV batteries
Number of battery packs	Total storage ÷ per-pack capacity	58,200 kWh ÷ 42 kWh/pack	**≈ 1,386 packs**	Rounded planning number

Battery Storage & Second-Life EV Packs

Item	Assumption / Input	Calculation	Result	Remarks
Area per MWh	Battery yard (incl. access, spacing)	—	**10 m² per MWh**	Conservative planning assumption
Total battery area	Storage × area per MWh	58 MWh × 10 m²/MWh	**≈ 580 m²**	Yard area for all non-mobility storage
Fraction of one block	Compare to 10,000 m² block	580 m² ÷ 10,000 m²	**≈ 0.058 blocks**	~6% of a single block footprint

Electricity Needs Calculation (Mobility)

Item	Value / Calculation	Result	Remarks
Number of buses	50 units	—	Daily 150 km, 1.3 kWh/km range: 0.9-2.5, take 1.3 as assumption
Number of EV cars	3,000 units	—	Daily 25 km, 0.15 kWh/km
Number of e-bikes	1,000 units	—	Daily 10 km, 0.008 kWh/km
Operating days	365 days/year	—	Applies to all modes
PV block equivalents	—	**≈ 19 blocks**	—
Battery (1-day)	—	**≈ 21 MWh (~500 packs)**	—
Battery (half-day)	—	**≈ 10.5 MWh (~250 packs)**	—
Battery yard footprint	—	**100–210 m²**	Very small relative to block size

Electricity Needs Calculation (Mobility)

Item	Value / Calculation	Result	Remarks
Bus daily energy (per bus)	150 km × 1.3 kWh/km	195 kWh/day	—
Bus daily energy (fleet)	195 × 50	9,750 kWh/day	—
Bus annual energy	9,750 × 365	**3,558,750 kWh/yr**	**3.56 GWh/yr**
Car daily energy (per car)	25 km × 0.15 kWh/km	3.75 kWh/day	—
Car daily energy (fleet)	3.75 × 3,000	11,250 kWh/day	—
Car annual energy	11,250 × 365	**4,106,250 kWh/yr**	**4.11 GWh/yr**
E-bike daily energy (fleet)	1,000 × 10 × 0.008	80 kWh/day	—
E-bike annual energy	80 × 365	**29,200 kWh/yr**	**0.03 GWh/yr**
Total mobility annual demand	3.56 + 4.11 + 0.03 GWh	**≈ 7.70 GWh/yr**	Exact: 7.694 GWh
Daily mobility demand	7.70 GWh ÷ 365	**≈ 21.1 MWh/day**	Used for battery sizing

Electricity Needs Calculation (Mobility)

Category	Item	Value / Calculation	Result	Remarks
4.3 PV Capacity for Mobility	PV yield (Nosara)	1,530 kWh/kWp/yr	—	—
	Required PV capacity	7,694,200 kWh ÷ 1,530	**5,028.9 kWp**	**≈ 5.03 MWp**
4.4 PV Area Needed	Panel density	0.2 kWp/m²	—	—
	PV panel area	5,028.9 ÷ 0.2	**25,144 m²**	Round: 25,100 m²
	PV-capable area (50% coverage)	25,144 ÷ 0.5	**50,288 m²**	Round: 50,300 m²
4.5 Blocks Required	PV-capable area per block	2,625 m²	—	From 525,000 m² ÷ 200
	Effective PV panel area per block (50%)	2,625 × 0.5	1,312.5 m²	—
	Block equivalents needed	25,144 ÷ 1,312.5	**≈ 19.16 blocks**	Rounded ≈ 19 blocks

Electricity Needs Calculation (Mobility)

Item	Value / Calculation	Result	Remarks
Daily mobility demand	21.1 MWh	—	—
Half-day critical backup	10.55 MWh → ÷ 42 kWh/pack	**≈ 251 packs**	~250 packs
Ground area (half-day) for battery storage	10.55 × 10	**≈ 106 m²**	Fits in small yard

Electricity Needs Calculation (Mobility)

Annual mobility demand	**≈ 7.7 GWh/yr**	—
Daily mobility demand	**≈ 21.1 MWh/day**	—
Required PV capacity	**≈ 5.0 MWp**	—
PV panel area	**≈ 25,100 m²**	—
PV-capable area	**≈ 50,300 m²**	—
PV block equivalents	**≈ 19 blocks**	—
Battery (1-day)	**≈ 21 MWh (~500 packs)**	—
Battery (half-day)	**≈ 10.5 MWh (~250 packs)**	—
Battery yard footprint	**100–210 m²**	Very small relative to block size

Electricity Needs Based on Housing Types

Item	Method 1 – Per-Capita (Costa Rica Avg.)	Method 2 – Block / Unit-Based (DOE Table)	Comment
Basis	14,000 people × 2,529 kWh/person/yr	2,560 dwelling units × kWh/unit/day by type	Different starting point (people vs. units)
Unit energy use	2,529 kWh/person/yr (national avg.)	Medium unit: 50 kWh/day; Large unit: 80 kWh/day	Method 2 assumes higher, with US measures
Housing mix used	Implicit (all residents averaged)	1,600 medium units + 960 large units	Skewed toward larger, high-use homes
Daily demand	**≈ 116,400 kWh/day**	**≈ 156,800 kWh/day**	Method 2 is ~40,400 kWh/day higher
Annual demand	**≈ 42.5 GWh/yr** (after 20% overhead)	**≈ 57.2 GWh/yr**	Method 2 ≈ 35–36% higher
Includes overhead?	Includes overhead of 20% for growth/uncertainty	-	-
Lifestyle implied	Current **Costa Rica** average consumption	**High-amenity, AC-heavy** international	Important for narrative about Nosara 2050

Appendix J: Housing Development

Housing

Typology Code	Description	Storeys	Typical Units / Block	Where to use
L1	Patio / courtyard houses, all ground	1	**6–8 units**	Edges, slopes, village feel
L2	Duplex row (one unit per floor)	2	**8–10 units**	Low-density terraces
M1	Courtyard walk-up (around a green)	2	**16–18 units**	Town expansion, near services
M2	Small bar-buildings / walk-ups	3	**20–24 units**	Closer to town center / transit
C1 (optional)	Compact mixed-use (shops + flats)	3–4	**24–32 units**	Only in core, not everywhere

Block Numbers

Block Type (from Table 1)	Density Level	# Blocks	Approx Units / Block	Total Units
L1 / L2	Low	**120**	~8 units	**960**
M1 / M2	Medium	**80**	~20 units	**1,600**
TOTAL	—	**200**	—	**2,560**

Policy Recommendations

- Water treatment laws
- Jobs reserved for locals
- Tourism Impact Fees
- Low Impact Development (LID)
- Limits on car ownership
- Maintain nature/coastal protection.
- Transfer of Development Rights
- Establish watershed management authority
- Mobility hierarchy
- Affordable housing
- Multi-Benefit Project Requirement

Appendix J: Model Development