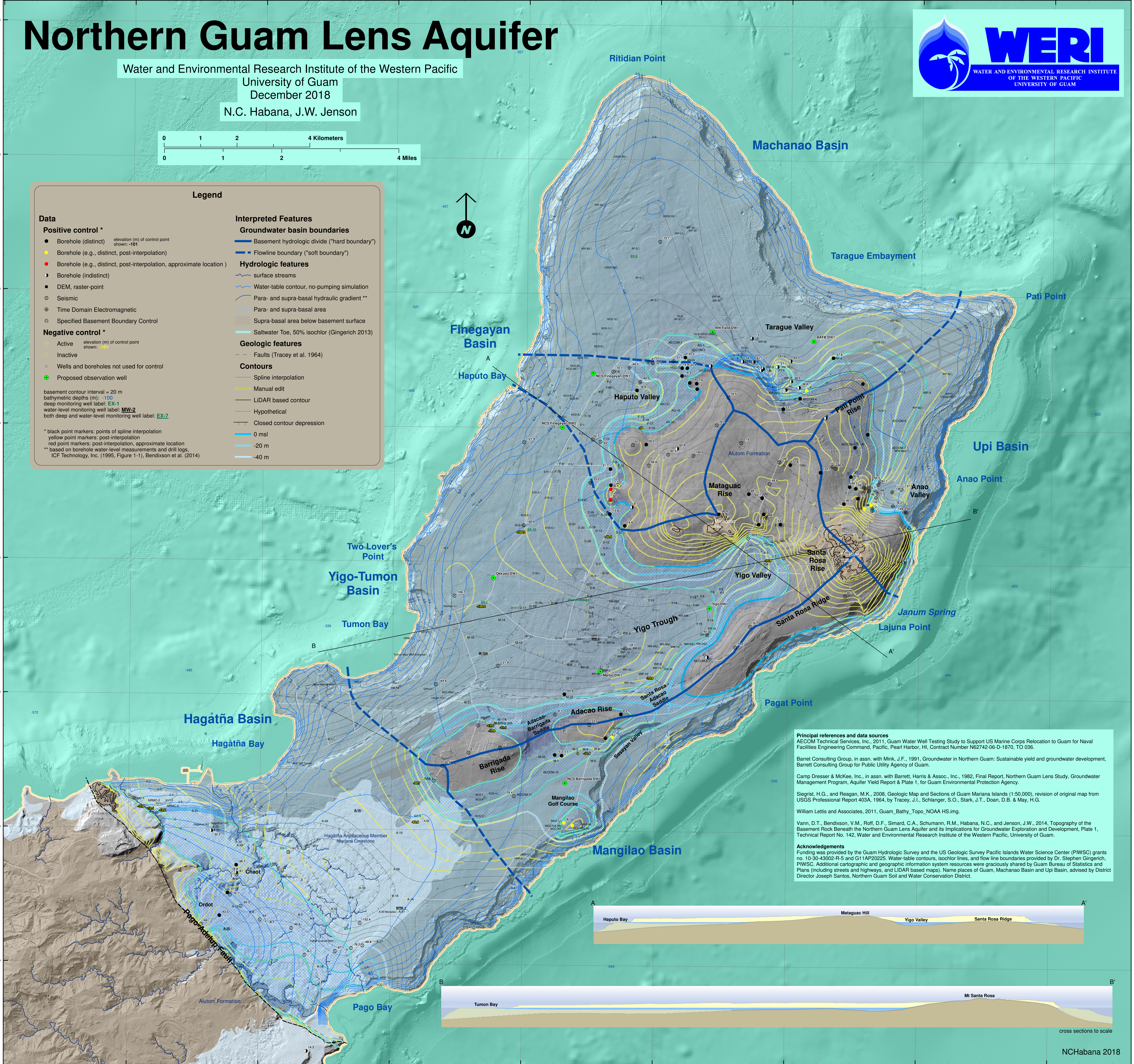
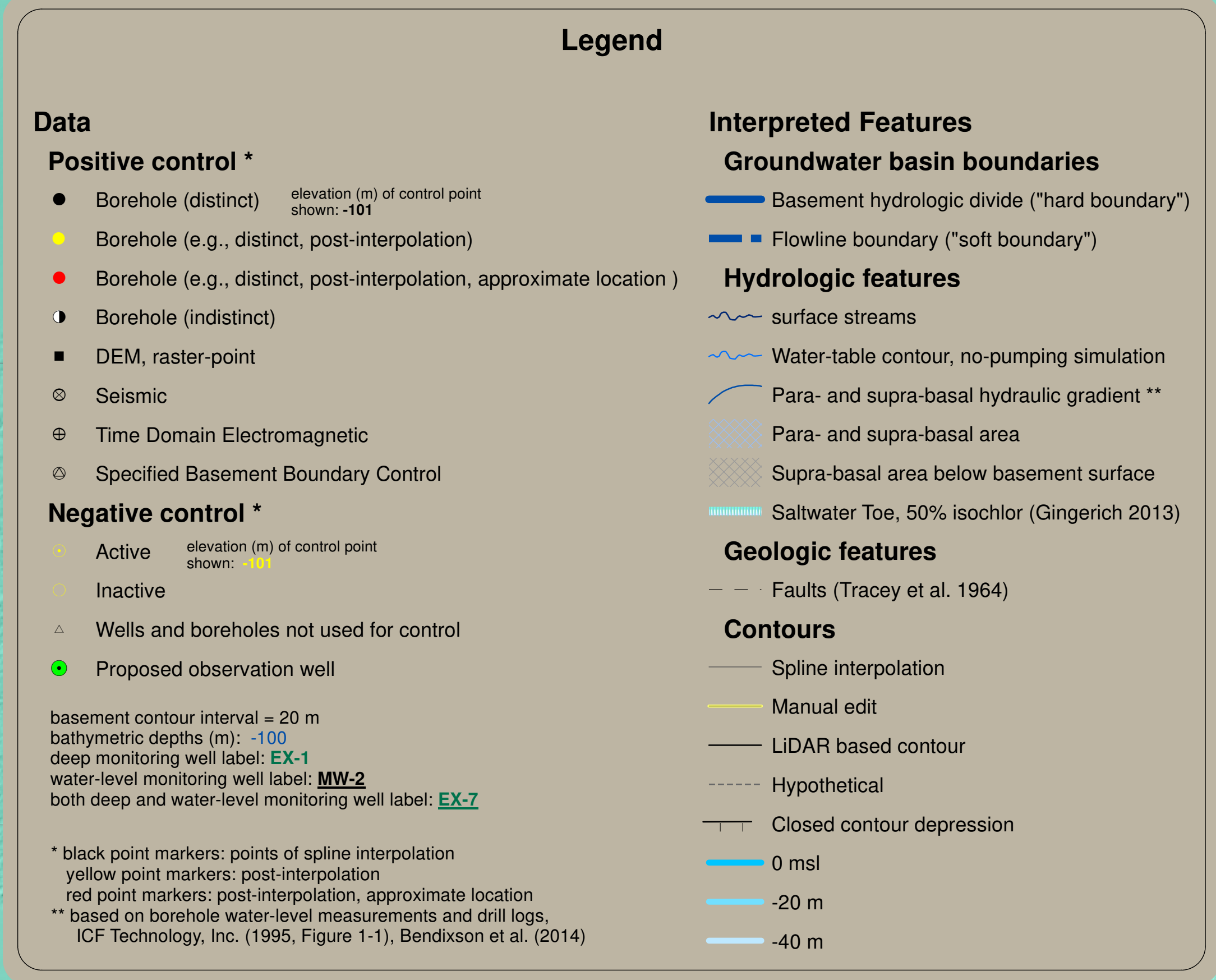
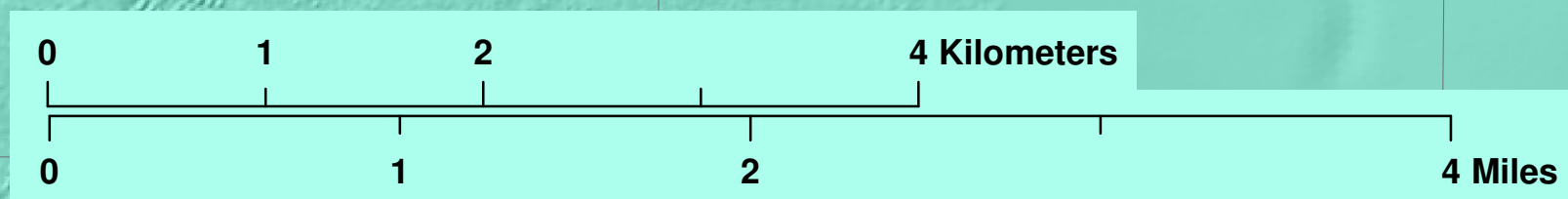


# Northern Guam Lens Aquifer

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**Principal references and data sources**

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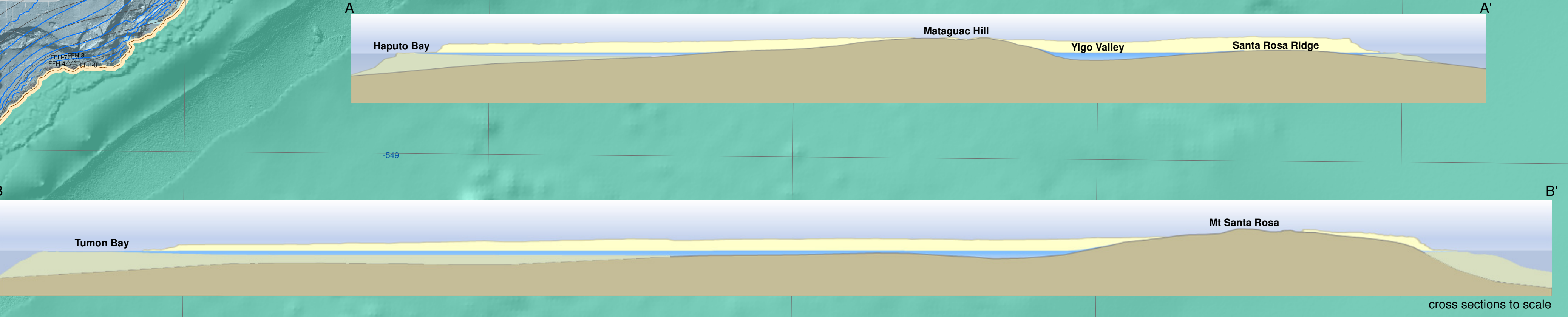
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**Acknowledgements**

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## THE NORTHERN GUAM LENS AQUIFER

The Northern Guam Lens Aquifer (Figure 1) is composed of very permeable limestone bedrock (Figure 2) that lies atop low-permeability volcanic basement rock (Figure 3). Rises and ridges in the basement rock that stand above sea level partition the aquifer into six semi-contiguous subterranean groundwater basins. Within each basin, freshwater is found in three distinct zones (Figure 4). Each of the three groundwater zones affords certain advantages while also presenting different challenges for groundwater exploration, development, and management.



Figure 1. Northern Guam Plateau. The Northern Guam Plateau, in an aerial photo, looking southeast from Two Lover's Point. Standing at some 200 to 600 ft (60 to 180 m) elevation, with 102 mi<sup>2</sup> (264 km<sup>2</sup>) area, the plateau surface is the uplifted, eroded remnant of an ancient atoll-like reef-lagoon complex. It is now the catchment for the aquifer composed of the Miocene-Pleistocene limestone bedrock sequence beneath it.

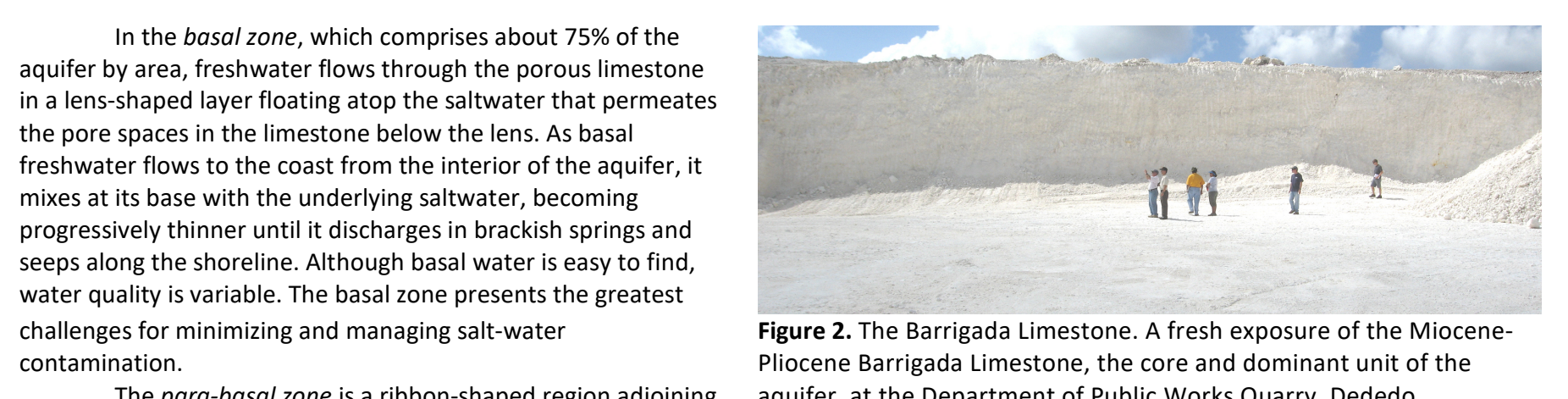


Figure 2. The Barrigada Limestone. A fresh exposure of the Miocene-Pliocene Barrigada Limestone, the core and dominant unit of the aquifer, at the Department of Public Works Quarry, Deddo.

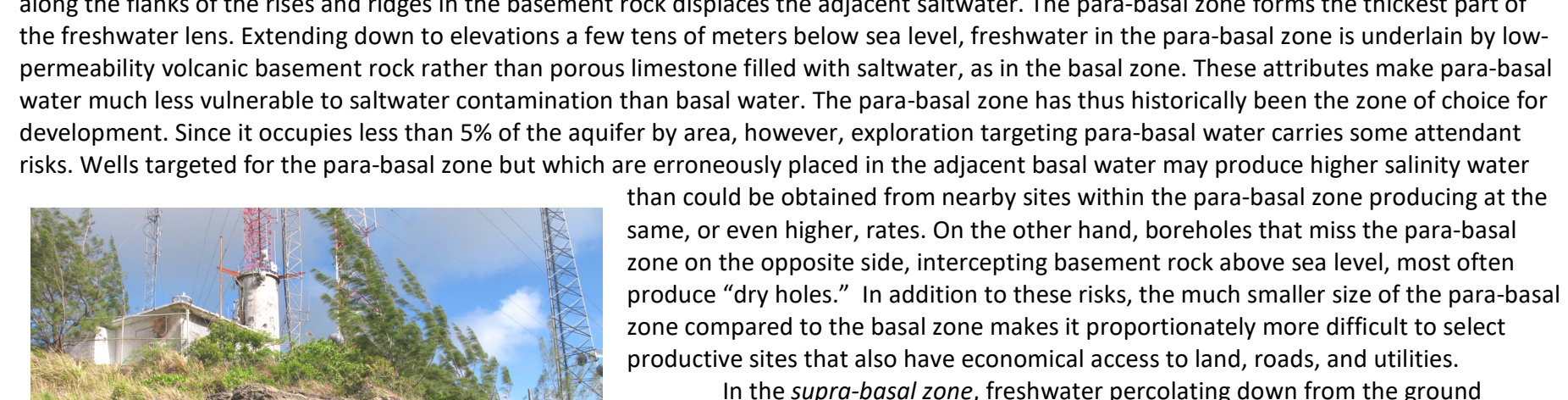


Figure 3. The Autum Formation. Outcrop of layered tuffaceous volcanic rock near the summit of Mount Autum, the type locale of the Oligocene Autum Formation, which on the northern plateau comprises the basement under the limestone bedrock aquifer.

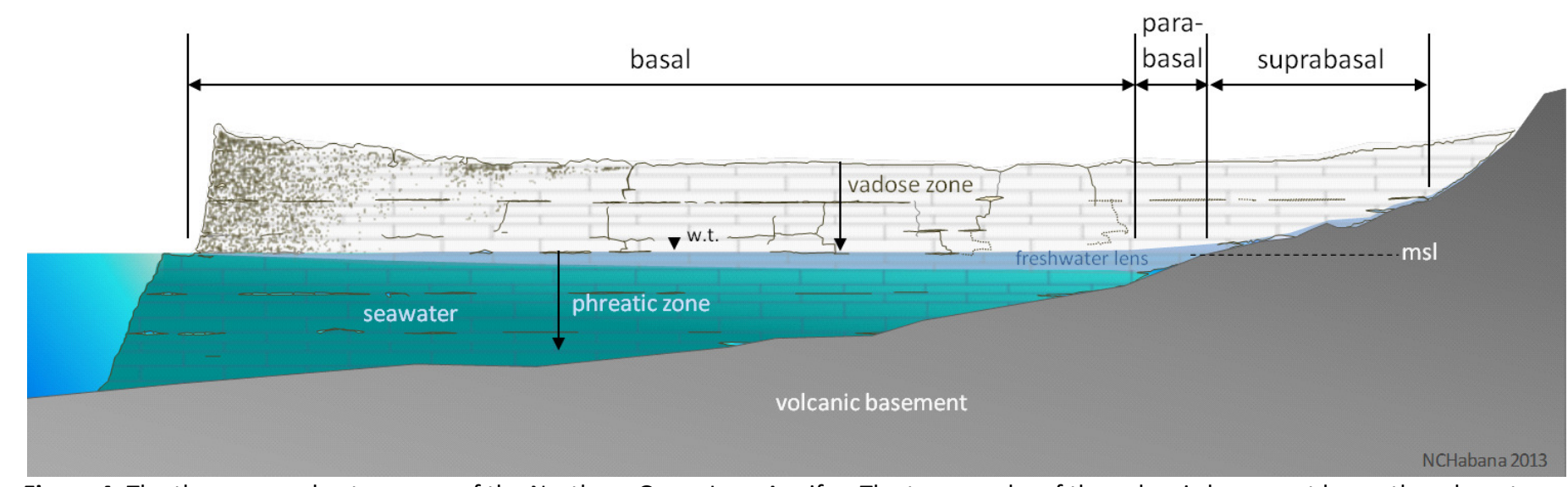


Figure 4. The three groundwater zones of the Northern Guam Lens Aquifer. The topography of the volcanic basement beneath carbonate island karst aquifers defines three groundwater zones (not to scale): 1) the basal zone, in which the freshwater lens is underlain by seawater; 2) the para-basal zone, where the freshwater is underlain by basement rock below sea level; and 3) the supra-basal zone, in which freshwater lies above sea level, on the flanks of the basement rises and ridges.

Given the complexity of these considerations, the most fundamental tool for groundwater developers, modelers, managers, and regulators seeking to optimize production from the aquifer is an accurate and detailed map of basement topography and its consequent groundwater basins and zones. The first such map was produced from geophysical and borehole data obtained during the pivotal 1982 Northern Guam Lens Study<sup>1</sup>. The map shown on this poster is the first published revision in the subsequent three decades<sup>2</sup>. Prepared in support of the 2010-2013 *Guam Groundwater Availability Study* led by the USGS<sup>3,4</sup>, the new basement map builds on the original 1982 data set, with revisions based on new, unpublished data accumulated since 1982 and consolidated by WERI. It also incorporates new insights gained from the broad-ranging 2010 *Exploratory Drilling Program* funded by *Naval Facilities Engineering Command Pacific*<sup>5</sup>. The new map updates and more precisely defines the boundaries of the aquifer's six groundwater basins. It also provides more accurate and detailed demarcation of the three groundwater zones within each basin. Names from the 1982 map are retained, but formal names are also assigned to previously unnamed but significant features. The new revision applied state-of-the-art screening and spatial analysis techniques to evaluate 697 records, from which 148 internal control points (80 from borehole data and 68 from geophysical surveys) were selected and applied along with 24 boundary conditions (2 LiDAR raster-points, 17 bathymetric points, and 5 specified points) to constrain basement topography. For each control point, the new map indicates the source or type of data (boundary condition, borehole, seismic, or time domain electromagnetic), type of control (positive or negative), and precision of control (distinct or indistinct). Elevations across the basement surface were thus interpolated from 273 control points, including the 24 along the boundary. Of the 148 internal control points, 132 positive control points provide absolute control for basement elevation, and 16 negative control points provide minimum measured depths of the limestone bedrock where the depth to the basement is otherwise unknown. Data used to build the map are summarized in Tables 1 and 2, below.

Data Type	Data Source	Disposition of screened data							Total screened each source
		Positive control			Negative control				
		Applied Active	*Set aside	Total screened	Applied		*Set aside	Total screened	
					Active	Passive			
Borehole	PIUAG, EarthTech, GWA	32	2	35	9	96	36	140	175
	Navy (inc. AECOM)	2	0	2	3	7	24	34	36
	AF (inc. IPR)	16	0	16	0	10	191	201	217
	WERI	2	0	2	4	6	12	23	25
	USGS	3	0	3	0	0	32	32	35
	Private	9	1	10	0	0	31	31	41
	Unknown	9	1	10	0	0	31	31	41
	Total boreholes	65	3	68	15	120	326	461	529
	Seismic	45	36	81					81
	TDEM	23	64	87					87
TOTAL all sources		132	103	236	16	120	326	461	697

\*Reasons for setting aside data include missing attributes, missing drill logs, lithology not discernible, data-rich area in which additional data are redundant or unnecessary, or data disagrees with borehole data (the last reason is applicable to seismic and TDEM only).

Table 1. Summary of internal control data: sources and disposition of all data screened. See Table 3, WERI Technical Report No. 142.

Type Control	Boundary Conditions	Internal Control				Total
		Borehole		Seismic	TDEM	
		Distinct	Indistinct			
Positive control	24	46	19	45	23	157
Negative control		15				15
Total	24	61	19	45	23	172

Table 2. Summary of active applied control points. See Table 4, WERI Technical Report No. 142.

<sup>1</sup> COM (1982), Final Report, Northern Guam Lens Study, Groundwater Management Program, Aquifer Yield Report, Camp, Dresser and McKee, Inc. in assn. with Barrett, Harris & Associates for Guam Environmental Protection Agency.  
<sup>2</sup> Vann, D.T., Bendixson, V.M., Roff, D.F., Simard, C.A., Schumann, R.M., Habana, N.C., and Jensen, J.W. (2014). Topography of the Basement Rock beneath the Northern Guam Lens Aquifer and its Implications for Groundwater Exploration and Development. WERI Technical Report No. 142, Mangilao, Water & Environmental Research Institute of the Western Pacific, University of Guam. 71 p.  
<sup>3</sup> Vann, D.T., Bendixson, V.M., Roff, D.F., Simard, C.A., Schumann, R.M., Habana, N.C., and Jensen, J.W. (2010). Groundwater availability study for Guam: goals, approach, products, and schedule of activities. USGS Fact Sheet 2010-3084.  
<sup>4</sup> Vann, D.T., Bendixson, V.M., Roff, D.F., Simard, C.A., Schumann, R.M., Habana, N.C., and Jensen, J.W. (2010). Groundwater availability study for Guam: goals, approach, products, and schedule of activities. USGS Fact Sheet 2010-3084.  
<sup>5</sup> Gingerich, S.B. and Jensen, J.W. (2013). The effects of withdrawals and drought on groundwater availability in the Northern Guam Lens Aquifer, Guam, U.S. Geological Survey Scientific Investigations Report 2013-5216: 76 p.  
<sup>6</sup> AECOM Technical Services Inc. (2011). Guam Water Well Testing Study to Support US Marine Corps Relocation to Guam. Pearl Harbor, HI, Naval Facilities Engineering Command, Pacific. Contract Number N62742-06-D-1870, TO 036.