Building with Nature & Beyond

Integrated Building with Nature Assignment

Example Answers for the 6 Pre-prepared Cases

To assess your own integrated Building with Nature designs, we ask you to compare your answer with the example answers for each of the six pre-prepared case studies. These answers were selected as exemplars from submissions by participants in the Massive Open Online Course Engineering: Building with Nature. There are 2 or 3 example answers per case study, presented in the following order:

- Case 1: Climate-proof Noordwaard
- Case 2: City with Nature
- Case 3: Fish Manager
- Case 4: Coastal Protection
- Case 5: Harlingen_Harbour
- Case 6: Flood-proof Indonesia

The comparison is undertaken on the basis of the factors and associated questions in the Self Review Table on page 5-214 of the book Building with Nature & Beyond (Slinger, 2021), while instructions on how to conduct the self review are provided in the video:

Nava Guerrero, G.d.C. (Graciela) (2016): *Engineering: Building with Nature 101x video #11 - Peer Review of the Building with Nature Design Assignment.* 4TU. ResearchData. Dataset. https://doi.org/10.4121/uuid:b9dbb185-0c94-46e1-af71-c51f860c8c2f

We strongly advise that you complete your own integrated Building with Nature Design assignment before reading further. You can also compare your solution with the details of the nature based solutions implemented in practice at each of the study sites (in Section 5.2 of the book Building with Nature & Beyond).

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Building with Nature Design Assignment

Case Title & Location:

Climate proof, Noorwaard

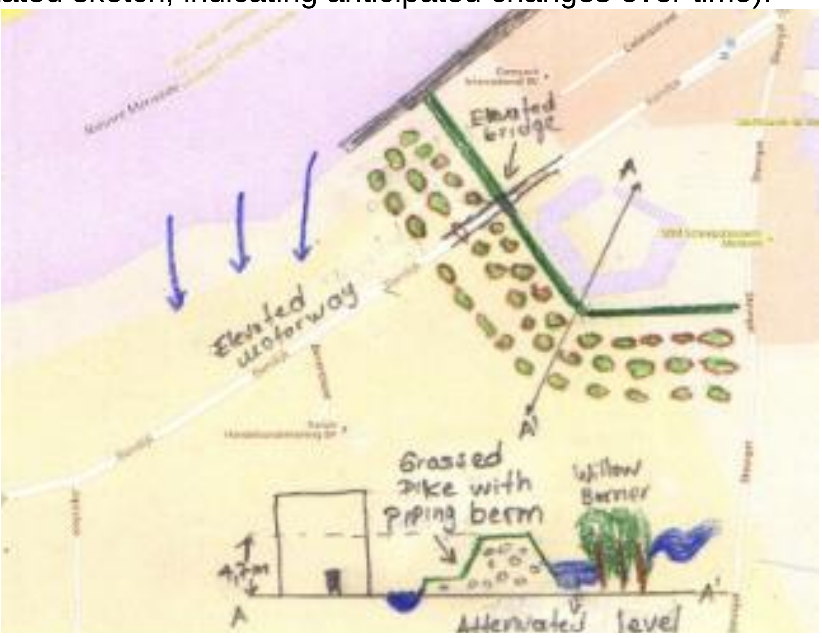
Functional Requirements (list at least 4):

- Increase the room for the River of Merwede by de-poldering.
- Protect cultural patrimony from flooding and wave effects caused by the action of de-poldering. The protection level needs to be at least 1/2000.
- Provide an eco-friendly solution to protect the cultural area (Fort Steurgat).
- Restoration of Tidal Inlets to Bieshbosch reserve (freshwater tidal wetland) and opportunities for local species.
- Maintain view conditions of the zone's residents (in case of a new Dike) and agriculture.

Design Sketches:

Conventional solution (annotated):

BwN design (annotated sketch, indicating anticipated changes over time):



Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles		**Checkboxes** Minimum - Maximum					**Explanation**
	1. Requisite standard					**X**	Standard conditions of the Dike are fulfilled with protection level (1/2000) and wave condition are controlled by the vegetation (according model in SWAN).
	2. Control variability				**X**		The Willow trees can attenuate the *variability of waves* ensuring the accessibility and safety in Fort Steurgat and in the surrounding households.
	3. Reasonable costs			**X**			With the use of Willow avoid the use of outer berm, or use concrete and other reinforcements. Because of that we can build a grassed Dike which represents an enormous reduction in costs. However, this system requires attentive maintenance, elevated motorways and compensation to farmers (sometimes relocation and construction of mounds) .
	4. Structural integrity					**X**	The dike is designed to guarantee the resistance to loads. It is also added a piping berm to prevent seepage under the dike and piping in its toe.
	5. Reliability				**X**		The willow trees need to be constantly observed because this system it has not been tested in a real scenario, because of that, at the beginning, it is required contingency measures to avoid a reduction in this criteria .
	6. Implementability			**X**			Although Willow trees are sturdy to flood conditions, in this case their resistance to this special use has not been tested, nor built in a real scenario but it is promising.
	7. Adaptability				**X**		Even if this solution in terms of future engineering uses are limited, it is possible to take advantage of ecological activities such conservation and ecoturism. Due to the reduction in the height of the dike residents can admire in better way the landscape.
	8. Resilience					**X**	Due to the calculations has been done with regard protection level 1/2000, with a fetch and wind speed(10Km and 30 m/s respectively) higher than in the current conditions, the system is able to withstand different flood scenarios.
	9. Appropriate boundary conditions and loads				**X**		The numerical model SWAN has cosidered the conditions of Willow trees (including variables such as the diameter, density height, and drag coefficient).

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles		**Check boxes** Minimum - Maximum					**Explanation**
	Continuity					X	De-poldering Noorwaard polder allows to reconnect the river system with the Bieshbosch reserve, for example restoring Tidal inlets. This finishes the current fragmentation of the ecosystem.
	No direct human disturbance			X			Some parts of the Noorwaard polder could be used for cattle farming. Also the willow barrier require constant verification and probably replacement of some individuals.
	Indigenousness / Endogeneity				X		Because the particular conditions of wetlands invasive species probably would no survive; instead, the conditions for the original ones could be favoured. However, it is uncertain.
	Viability of populations			X			Although the original conditions of the wetland are re-established, only in middle and long term this condition could be verified. The willow trees could increase in number which is positive.
	Opportunity for threathened species					X	Expand the territory of beavers and voles could stimulate its reproduction. Also expand the borders to develop tertiary vegetation.
	Trophic web integrity			X			Although the original conditions of the wetland are re-established, only in middle and long term this condition could be verified.
	Opportunity for ecological succession				X		The Tidal inlets allow the formation and strengthening of pioneer species . However it is necessary recognise that some of them could be affected for cattle farming.
	Zone integrity					X	This system connects directly in surface the water of the river with the wetlands, bringing more nutrients to the zone and processes can develop as it was before the construction of the traditional dikes.
	Characteristic (in)organic cycles			X			There are certain uncertainty. Bieshbosch reserve and the surroundings to Fort Steurgatand adapted to the conditions without tidal inlets for so many years.
	Characteristic physical-chemical water quality				X		New oxygen introduction to the ecosystem. Nonetheless, it is required to examinate that some wetlands do not result damaged.
	Resilience					X	Because water connections are re-established it is really probable that the willow's barrier and the ecosystem of Bieshbosch adapt to flooding.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

In the future the BWN different activities needs to be accomplished such as:

- Constant assess of the effect of the waves in the willow Barrier and the state of the trees during and after a flooding.
- Monitoring the state of the grassed dike and of the piping berm. Furthermore, take preventions if the willows system do not work as in the simulations.
- Assess the effects of the inlet tidal of the River of Merwede in the Biesbosch reserve.
- Monitoring the agricultural and cattle farming activities in the area in order to avoid exposing species and ecosystems.
- Analyse the new offers environmental benefits of the Dike and de-poldered area such as ecotourism and preservation of species.

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

BWN broadens the possibilities for any project because integrates specific knowledge into a holistic approach in order to understand the interactions between the environment and human developments; this produces more sustainable solutions with added value for nature. A clear example is the approach in Noorwaard which not only focus in the construction of a dike, but also this integrates nature as an active part of the designs (willow barrier).

Additionally, the design in Noorwaard considers as a key point in the design the reconnection of an ecosystem (River of Merwede and Biesbosch wetland) and at same time continuing to offer view conditions and agricultural activities to the inhabitants.

Although there are several benefits in the project, it exists certain uncertainties with regard of how the Biesboch reserve will react to flood conditions, also if the barrier of willows will behave as predicted and if endogenic species will increase with the transformations. However, because the new dike allows re-establishing the original conditions in the wetland ecosystem, it is really possible that each component is beneficed.

The labour with the BWN design also considers the impacts to agriculture and considers inhabitants as part of the solution.

Building with Nature Design Assignment

Case Title & Location:

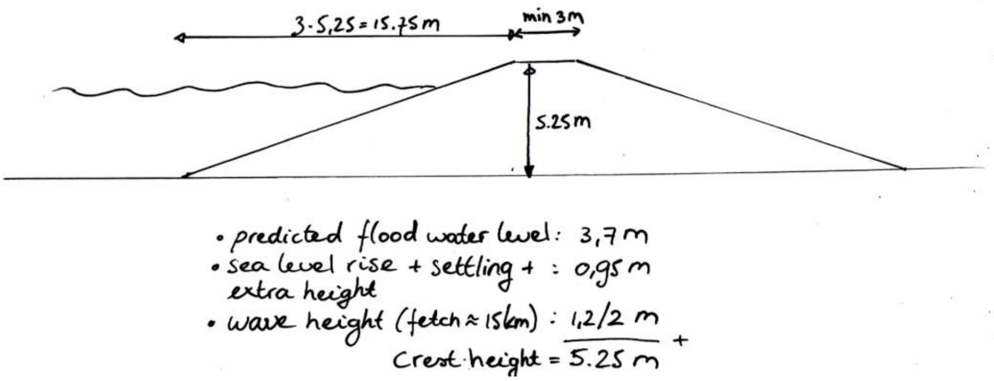
Noordwaard Polder, Noord-Brabant

Functional Requirements (list at least 4):

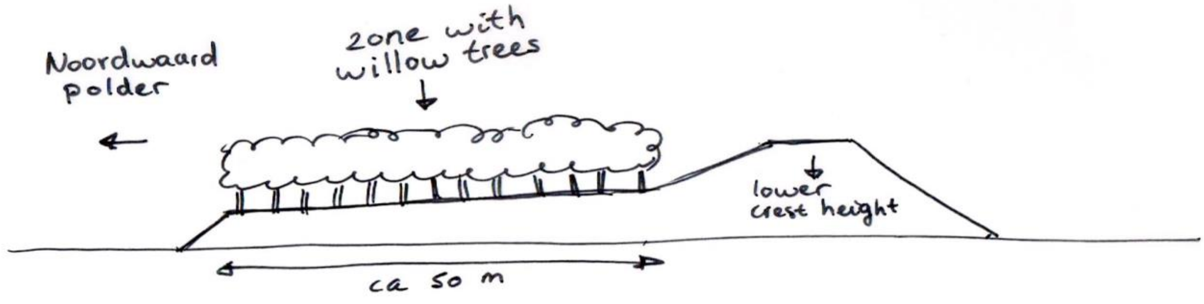
- Protection of fort and households against flood event with annual probability of occurrence of 1/2000.
- Withstand erosion
- Provide opportunities for the ecosystem currently present and developing in the polder
- Create a recreational space for inhabitants and preserve the view as much as possible

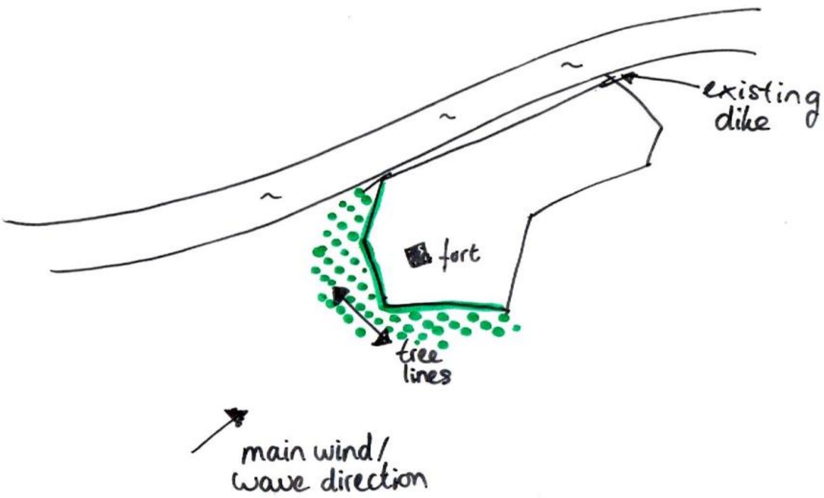
Design Sketches:

Conventional solution (annotated):



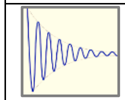
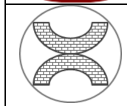
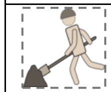
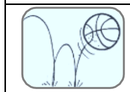
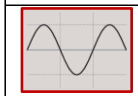
BwN design (annotated sketch, indicating anticipated changes over time):



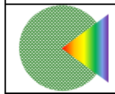
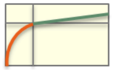
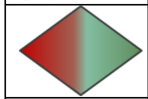
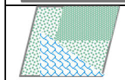


Using a 50 m zone of willow trees will lead to an approximately 70% reduce of wave height = 0,84 meter instead of 1,2 m. This means the total crest height will be reduced by ca. 20 cm (which I think is not really a lot actually).

Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles		**Checkboxes** Minimum - Maximum					**Explanation**
	1. Requisite standard					x	It is designed to the standard of a 1/2000 year flood event
	2. Control variability				x		Although it isn't designed to control flood events, it does control wave variability by reducing the wave height.
	3. Reasonable costs				x		The costs of a willow zone are substantially lower than raising the crest of the dike or strenghtening the revetment.
	4. Structural integrity				x		Naturally, the dike should be built in a way it ensures the structural integrity.
	5. Reliability			x			Fallen or dying trees need to be replaced to keep the design reliable.
	6. Implementability			x			There is a lot of experience with building dikes, and this is in fact just an adjusted dike. The willow zone might be a bit new though.
	7. Adaptability			x			Some changes can be made, although the dike is quite a fixed structure. The zone of trees can be adjusted or extended for in the future.
	8. Resilience				x		It should be able to resist several floods, but it might be possible that the trees need repair after one.
	9. Appropriate boundary conditions and loads				x		The effect of vegetation on wave conditions was tested with the SWAN model.

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles		**Check boxes** Minimum - Maximum					**Explanation**
	Continuity		x				The dike itself is a barrier, although the willow zone forms a continuity of the polder ecosystem.
	No direct human disturbance			x			This depends on whether people can enter the dike and zone for recreation.
	Indigenousness / Endogeneity				x		Indigenous species are used for the design. It is unclear whether invasive species will be attracted as well.
	Viability of populations				x		There is no reason to think the design forms a risk for existing populations.
	Opportunity for threathened species		x				The design doesn't really focus on threatened species.
	Trophic web integrity			x			The effects on trophic web integrity are unclear, needs monitoring.
	Opportunity for ecological succession				x		Along the ditches in the Noordwaard, there is now space for pioneer plants again. The willow zone forms a part of the succession.
	Zone integrity				x		Instead of a abrupt dike, there is now a more gradually zoning from river to dry land.
	Characteristic (in)organic cycles			x			Probably no changes – but unclear.
	Characteristic physical-chemical water quality			x			In the polder the water characteristics will change – due to inlet of river water during storm.
	Resilience				x		Adding a natural zone of willows does increase the resilience of the ecosystem.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

- Routine monitoring of dikes: flood protection. To test if the quality of dike is still good enough and according to the standards.
- Specialized ecological monitoring: how does the polder develop?
- Monitoring of recreational use. Does it have any negative influence on the dike/ecosystem?
- Monitoring to see if the willow zone stills fulfills its function or if maintenance is necessary.

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

+ better view for the inhabitants because of lower dike
+ cost effective since heigtening the dike is very expensive
+ new ecological zone and more gentle sloping of dike, leading to more diverse ecology.
- It is not really actively focussing on adding new valuable elements to the ecosystem, it is just improving the old concept of the dike.
- The tree zone might turn out to need a lot of maintenance, or adjustments over time.

Building with Nature Design Assignment

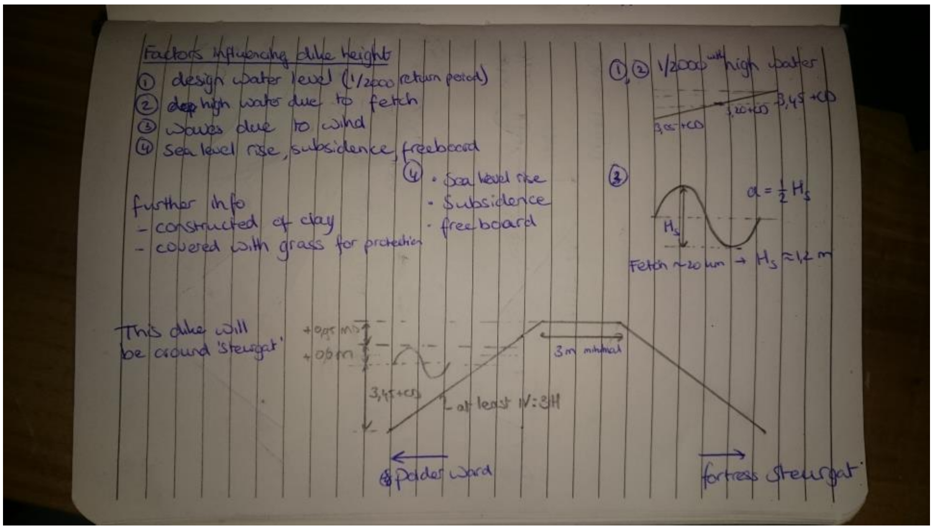
Case Title & Location:

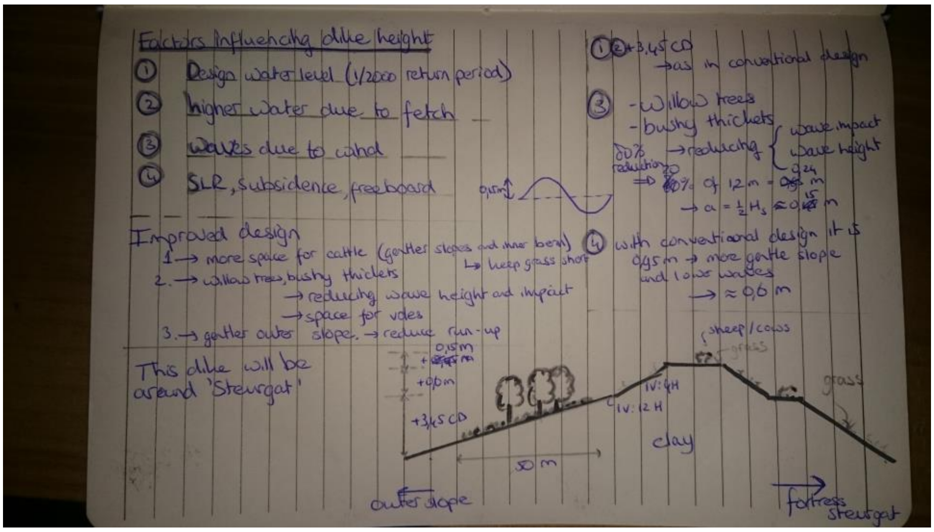
Climate-proof Noordwaard, Werkendam, The Netherlands

Functional Requirements (list at least 4):

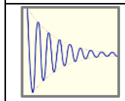
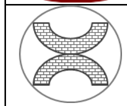
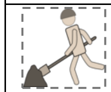
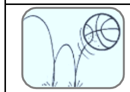
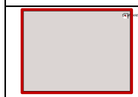
- Design level dike with a return period of 1 in 2000 years according to the Dutch Water Act.
- Maintaining aerial view from the ‘Steurgat’ fortress.
- Improve quality of living environment for common local species.
- Using local materials for construction.
- Conservation of existing ecosystems.

Design Sketches:

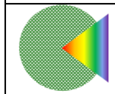
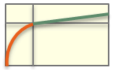
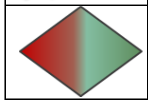
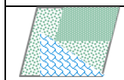




Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles		**Checkboxes** Minimum - Maximum					**Explanation**
	1. Requisite standard					x	The standard of a design level with a return period of 2000 years is chosen, which is consistent with the Dutch Water Act. The dike height is constructed within this boundaries.
	2. Control variability			x			The dike retains water, so in that way there is control on defending the hinterland. Thereby cattle and humans can cross de dike, due to the grass cover and mild slopes. There is no connection between the water at Steurgat and in the polder.
	3. Reasonable costs					x	Soil is often cheaper than concrete. Thereby, local materials are chosen, for example the clay present in the polder is used to construct the dike. Thereby are willow trees and bushy thicks also construction material, which is relatively cheap.
	4. Structural integrity				x		Grass covers the dike to protect the dike when it is overtopped. Soil has the possiblity to subside, so that is a negative side.
	5. Reliability					x	A dike in general is often very reliable, however periodical checks are needed to evaluate the influence of animals on the dike: holes of voles or rats might lead to piping. Cattle might damage the grass cover. Trees and bushes might be damaged.
	6. Implementability				x		There are many dikes in the netherlands. It is a very conventional design to protect the hinterland. This approach with willows and bushy thickes are observed less at the moment.
	7. Adaptability					x	The inner berm gives space to increase the dike more when needed. This might be needed when sea levels rise faster than expected.
	8. Resilience				x		The berm protects the inner part of the dike from sliding. The grass protects the dike for wave impact. Many research showed this is sufficient for wind waves.
	9. Appropriate boundary conditions and loads		x				In this case a simple fetch schematization is used. Thereby, relatively simple estimation are done on sea level rise etc.

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles		**Check boxes** Minimum - Maximum					**Explanation**
	Continuity				x		The water system becomes seperated due to the dike. However, cattle and other animals, still have their living environment. So it interrupts the water flow, but most ecosystems present are still connected.
	No direct human disturbance			x			Grass might be damaged however not very likely due to small load of humans on the grass cover. Thereby, bushes and trees might be damaged by the impact of humans.
	Indigenousness / Endogeneity					x	The bushy thickets realize a protected area for voles, which are an indigenous specie within this environment. Since the outer slope will be flooded sometimes a year, willow trees can survive more easy compared to other species.
	Viability of populations				x		Due to the protection by thickets it is hypothesized that voles can persist within this area.
	Opportunity for threathened species				x		Outside the Biesbosch voles cannot live that easy, creating the protected areas lead to better conditions for beavers and voles.
	Trophic web integrity						
	Opportunity for ecological succession		x				The constructed environment as designed should mainly remain the same, since those are designed specifically on reducing wave heights, run up and overtopping.
	Zone integrity				x		Since no 'hard' structures are used, each part interferes relatively fluent. However, in the beginning phase it will be more seperated.
	Characteristic (in)organic cycles				x		Hardly any change will occur on those organic cycles, since only local materials are used.
	Characteristic physical-chemical water quality			x			Water exchange from the fortress is more difficult, however, groundwater flow still gives rise to some exchange between the outer and inner part.
	Resilience			x			Since all materials are common in the surrounding, damage will possible be prepared by same vegetation species (grass). Thereby even dead plants and trees might reduce impact.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

This design is specifically for this situation. This means that damage on individual parts of the design might increase risk of failure.

Starting on the very mild outer slope, trees and thickets defend the dike. Controlling the state of this vegetation is important, to maintain the same risk of failure. Thereby, small animals which might be present within the bushy thickets dig holes on the slope, which might lead to micro instabilities in the soil, but also to piping in the dike. This is very important to know before high water is present.

It is also important to monitor the grass cover of the dike. It is less crucial than piping, so it can be conducted by a farmer with cattle grazing on the dike. Hawks can be used to maintain the vole population at a certain level.

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

A milder outer slope, as designed here, needs more soil than a conventional slope design. However, this slope gives opportunities for willow trees, bushy thickets and reducing wave run up.

The inner slope is also milder compared to the conventional design. This is designed because it is possible now for cattle to graze on the dike. Additionally, when cattle isn't present. It is possible to cut grass with a tractor.

It is not known in this case what the effect will be on giving such protective space for voles. It might be overpopulated leading to much holes in the dike for example. So the ecological benefit leads to more uncertainty on the evolution of the ecosystem.

Since it is desirable to have cattle on the dike to shorten grass. A farmer must be interested to place his/her cattle on the dike. This leads to more organization. In the end, all building with nature improvements on this design, seems to be very logical steps within the design process. However, this design might lead to more costs due to its uncertainty.

Building with Nature Design Assignment

Case Title & Location:

City with Nature : Nijmegen-Lent at river Waal, The Netherlands

Functional Requirements (list at least 4):

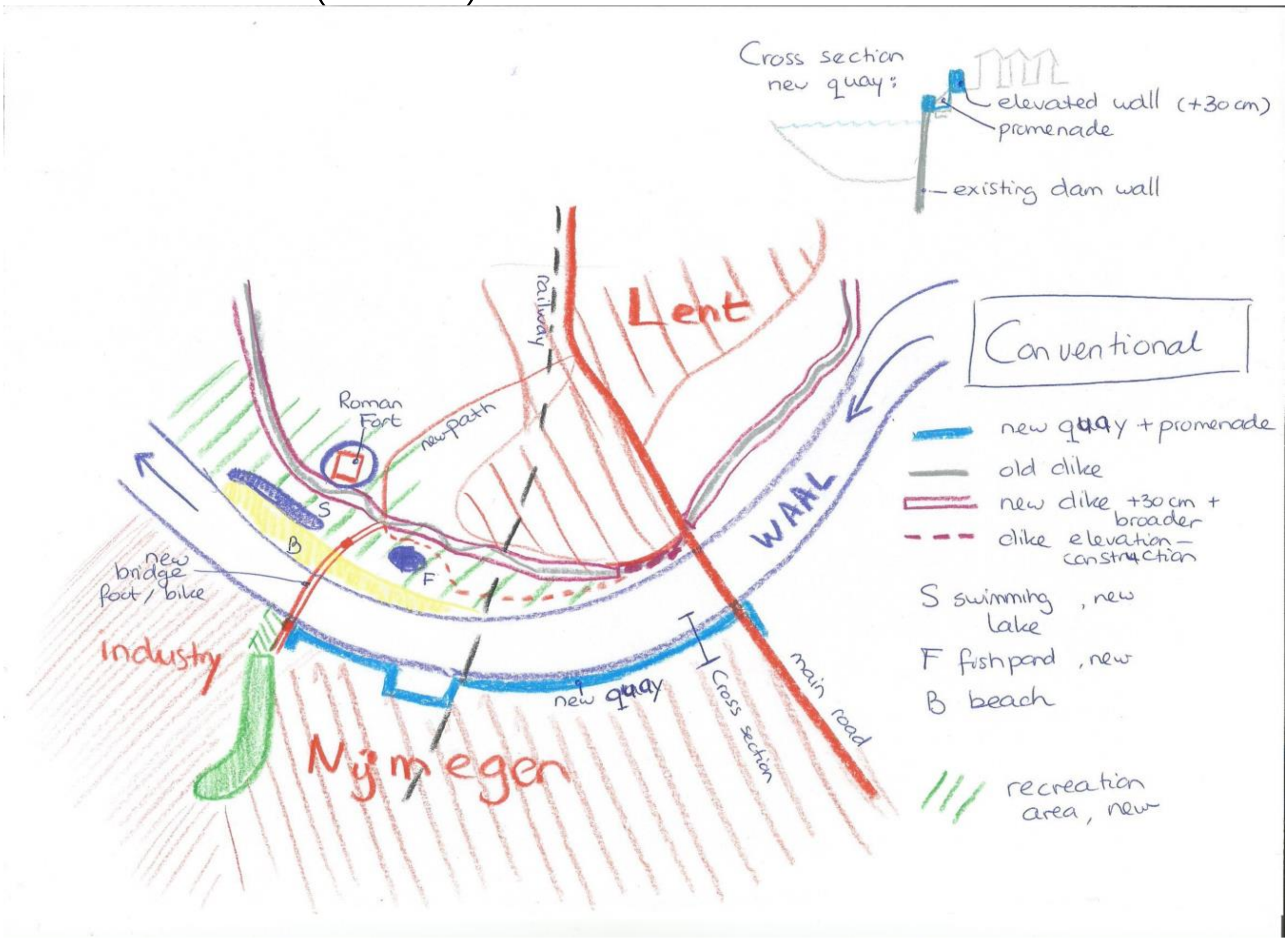
- maintain flood protection level at the standard 1:10.000 y
- adjust for an higher peak discharge of 30 cm at Nijmegen, to anticipate a future climate change
- maintain the nautical safety en quality at present level of use by freight ships
- improve quality for urban dwellers
- improve the connection between Nijmegen north and south

and for the BwN design only:

- improve the quality for regional river-ecosystems, at least for the following threatened types: pioneer vegetation at efemere sandy shores, a vegetated streaming riverchannel, grassland on high dry poor sandy “natural”banks, alluvial forest (high and dry type)
- allow for meandering where possible, with erosion and sedimentation of sand and clay
- diminish risk of overtopping of dike by use of natural vegetation
- maintain at least 50% of the homes between the present dike and Nijmegen north.

Design Sketches :

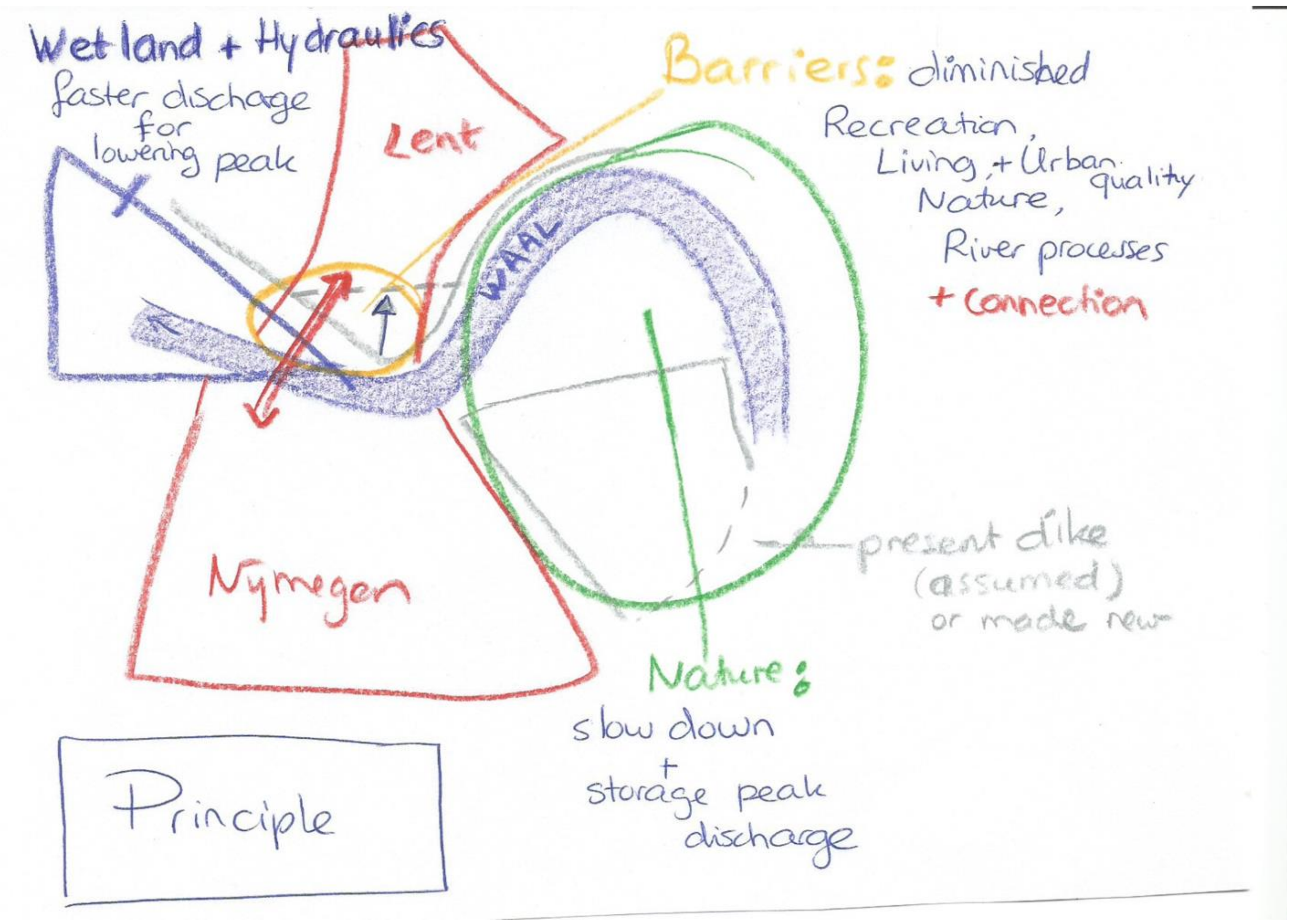
Conventional solution (annotated):

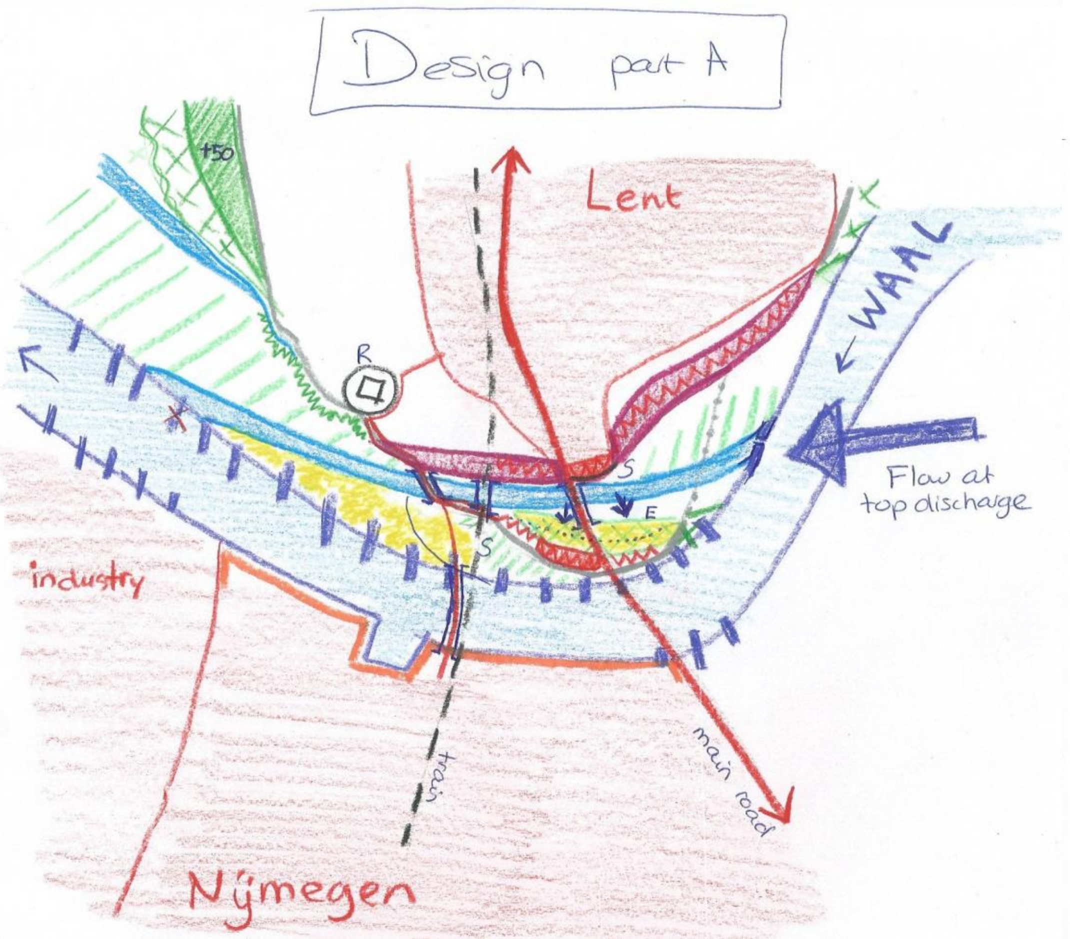


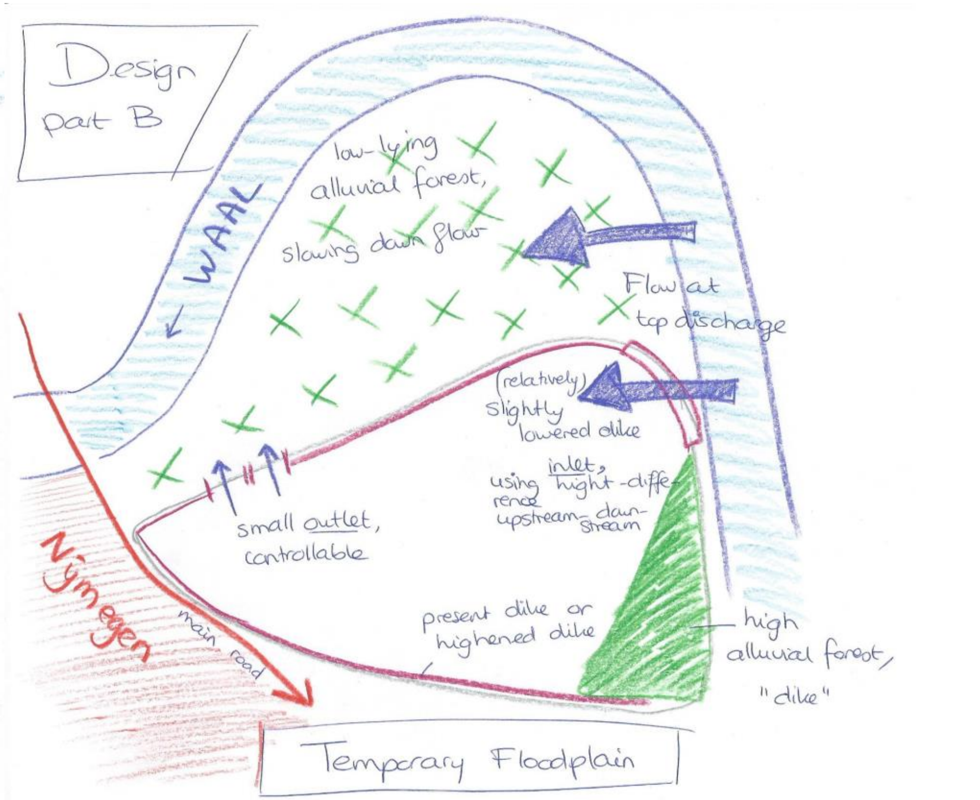
Aerial photograph used as base for my designs. I needed to know the flow direction at peak discharche, and I was intriged by the wide grassy floodplain upstream.
So I looked up in Google earth the lay out of the riverbed and diked floodplain directly upstream.
So part B of my design is additional to the assignment: the green circle in the principle / concept sketch.

BwN design (annotated sketch, indicating anticipated changes over time):

0 Principle of the design:





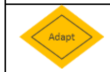
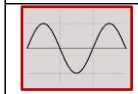


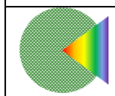
Design explanation

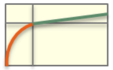
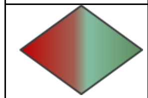
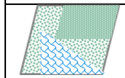
- new broad dike with quay-houses on top (+50cm), Riverfront
- new channel + inlet-construction + direction of meandering →⋮
- existing houses / with "reinforcement"
- existing dike kept / removed
- lowered groynes
- new bridge
- new quay, promenade + 50 cm.
- new path (foot / cycle)
- existing dike-road / new bridge (cars residents)
- new houses. super-peak discharche-resistable or easy rebuildable
- steep sandy bank. buffer for erosion. against old dike. (+50 cm ?). threatened dry grassland (and dry alluvial forest)
- sandy river beach
- E→⋮ erosion area : steep outer slope, high grounds } dynamic
- S sedimentation area : gentle, low inner slope } dynamic
- lowered floodplain
- R Roman fort or other attraction point
- protecting shrubs on slope & dike for protection overtopping
- high / Low alluvial forest / forest on sandy bank against old dike / on sandy clay = original or lowered floodplain

Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles	Checkboxes					Explanation
	Minimum - Maximum					
1. Requisite standard					x	The Dutch flood safety protection standard 1:10.000 years is met at present and the way it is met will improve by this design. The design anticipates to keep the standard at future climate changes with larger discharge.
2. Control variability		x				Variability in discharge cannot be controlled, but peak discharge is topped off in several ways. And low discharge navigatability is mainatained, also in future climatic changes with larger discharge.
3. Reasonable costs		x				The costs are high, but the value of the area is enlarged by: new expensive houses with a view, economic chances for recreation by urban dwellers and (national) nature-lovers, and chances for more urbanisation in Nijmegen North.
4. Structural integrity				x		Not maximum. Shores of the island are mostly of sand only. Erosion may occur and that is allowed to an extent. Clever use of both the existing dike, the levee of the main road and the pillars of the bridges enhances the integrity of the island. The use of new sand banks against the existing dike (of perhaps partly non existing in design part B), are so big and out of reach of the main flow, that ist integrity is large, even made of sand / thick sand toplayer
5. Reliability					x	By relocating the dike and diminish other barriers, and designing by using the flowpatterns at high discharge, the design is very reliable. Very low maintanence of the hydraulic structure (second channel and island) . Less maintenance than on present floodplain (parts will become woodland in stead of maintained grass) the river floods keeps the sandy beaches free of vegetation. The second channel functions at high discharges, also when its water is filled with a lot of vegetation (at the water level of lower discharges)
6. Implementability					x	All the elements have been made before, so the design uses proven techniques. New is the making of an elevated bank (with forest) leaning against the old dike downstream and in the temporarily floodplain upstream, but shoveling sand against a dike is easy. Also fairly new (?) is make an outlet opening in the dike from the temporary floodplain in part B of the design, but this temparary outlet can be constructed like e.g. a sluicedoor, a gate of small weir. New (?) is using vegetation on (or on the foot of) the dike to prevent overtopping of

							river dikes. I assume it saves for costly 30 cm dike elevation. Even constructing dikes in existing houses is done before (Kampen city). Here something like that is needed tot safe the row of houses of Lent adjacent tot the new channel (to keep their vieuw, if possible).
	7. Adaptability					x	This is the key feature of the design; allowing for future changes in top discharge
	8. Resilience					x	The project is designed for a great resilience for many high and top discharges. The island is "oversized" in width, and well designed according to top discharge flow patterns, so it can withstand many high floods before it erodes to much (if erosion will occur at all)
	9. Appropriate boundary conditions and loads					x	The design is (in my imagination) checked and adjusted with use of the Rijskwaterstaat models for discharge height, flowpatterns, dike design hight rules and vegetation effects on peak levels.It uses new (now imagined) models based on scientific studies of the safety of a dike with species rich natural grass vegetation types on the dike.

Ecological principles		**Check boxes** Minimum - Maximum					**Explanation**
	Continuity					x	Provides for water and sediment flows and more gradual water-land transitions. Allows for sedimentation and erosion-processes and other natural river processes such as meandering. The Waal main channel is unchanged, the new channel is allways connected and streaming (exept for super low discharge, then the upstream river level is below a sill at the inflow. Then the waterconnection is only downstream.)
	No direct human disturbance		x				In an urban area there is allways human disturbance, escpecially in recreational area's and parts with houses and roads. But the design uses water and prickly indigenous shrubs to keep people away from some nature area's. Other areas provide for restored nature and can be used for recreation (grasland, sand flats), without many problems for nature. To an extent.
	Indigenousness / Endogeneity				x		The design is made for indigenous river ecosystems, and made of local material (river sand and clay). It cannot prevent foreign species to establish here (nothing can), but the design maximally provides for local species and complete ecosystems to better withstand foreign species

	Viability of populations				x		The design enhances several populations /river ecosystems (e.g. waterplants, breeding grounds for river fish, river dragonflies, beavers, alluvial forest, alluvial grassland-plants and butterflies). But the effect on present (bird)populations in the area of dike relocation is unsure: monitor and adjust
	Opportunity for threathened species				X		The restoration of threatened habitats is one of the aims of the project. In those habitats live threatened species. Not maximum because of human disturbance (birds most affected)
	Trophic web integrity					X	The project adds several river habitats that lack at the present, such as watervegetation, pioneer vegetation, alluvial forest, sandy grasslands. And with those habitats with primary production all the trophic layers on those vegetations: saprofytes, herbivores, carnivores
	Opportunity for ecological succession				x		Succesion stages that were lacking are now provided for: e.g. . River vegetations (low or ansent in Waal because of heavy natical use), and climax stages (forest). There is more opportunity for pioneer stages. There is more room for succession, as there will be higher grounds in the floodplain, so these grounds are not set-back in succession every flood.
	Zone integrity					X	The island and second channel are designed for a complete zonation from low inner bend with shallow slope via river channel with efemere shores to a high outer bend with a steep slope. This zonation will stay present but will shift in place when meandering processes take place. The zone of forest is added at some parts.
	Characteristic (in)organic cycles				x		By building with the local sand and clay the same cycles occur as when compared to natural sedimentation. Only the amount is bigger at once. The cycles of Carbon, N, P are restored somewhat by the room for river vegetation and river ecosystem.
	Characteristic physical-chemical water quality					x	The waterquality is improved a little by the filter capacity of the riverbed vegetation in the new channel. The groundwaterflow from the high grounds (Nijmegen) is not affected, because the new channel is shallower than the Waal and downstream from the groundwaterstream.
	Resilience					x	The ecosystems present and restored are able to withstand successive floods and can even benefit from it, as those floods trigger natural processes that form the abiotic conditions for those ecosystems. Such as accretion of sand, spatial shift of zones, reset of succession.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

To check:
Model or calculate the amount of peakshaving at Nijmegen with this design's combination of measures : adds up to at least the set requirements of 30 cm at peak discharge?
For design part B: See if there are cities or other important zones present upstream, that cannot handle the risk of backflow used here with a temporary floodplain and retention. Whatsoever, With the functional requirement here of withstanding +30 cm peak discharge, the whole river system should be made climate proof.
Assess the risk of :
-an unnatural design: A check has to be made (I should have done it beforehand) if a second channel in the floodplain and this type of secondary channel is characteristic for this part of the river Waal, according to the Dutch SMART Rivers principle. Adjust design accordingly.
-erosion of island and the pillars of the bridges by top discharge. Model how fast the new channel will meander southwards towards houses on island. Should be 150 years at least. Adjust design to flow pattern. Last option: Reinforce the heads when necessary (preferably in design). Monitoring needed
-to much inflow in new river channel at low discharge, hampering nautical conditions in Waal main channel. Model analysis, adjust design of inflow.
-enlarged sedimentation in main river channel (nautical problems). Monitoring needed
-Viability of present populations, Monitor beforehand which populations are present and may be negatively or positively affected. Monitor afterwards.
-too expensive
-too many people strongly against it. Find out why.
-too many houses affected

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

This design uses the process of meandering for gaining a near complete natural zonation and keep it present for a considerable time in future. The location of the second channel is allowed to shift a bit.
The design uses local sand and clay to form indigenous river structures as sandbanks and flats. They are used for safety and they provide room for ecosystems as river grasslands and forest on "high" laying ground in the floodplain.
It uses forest and shrubs to protect dikes and retain the peak flow before it reaches the city.
It gives room for lacking ecosystems, like vegetated riverbed and sandy grassland. The new channel is not for vessels, so it enables a threatened river vegetation and thus river ecosystem to grow. I assume they lack in the present Waal.
It restores part of the floodplain.

In design part B I have chosen for keeping agricultural use and thus a temporary floodplain. Because of costs (not buying all the ground). Better for riversystem and ecology is dike relocation for the whole upstream area in the design, and fill it with forest and reedbeds, to retain the discharge. Good for populations of beaver, eagles, herons, wetlandbirds.

Building with Nature Design Assignment

Case Title & Location:

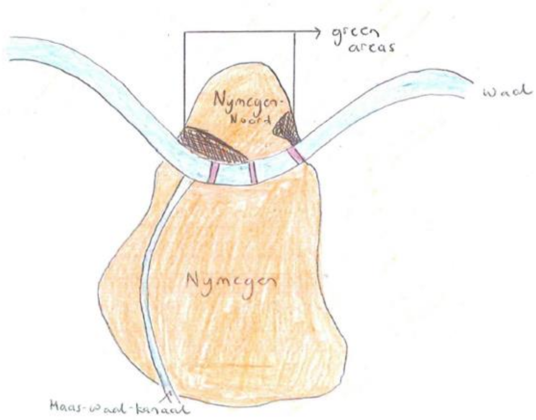
Building with Nature design for River Waal, Nijmegen (The Netherlands)

Functional Requirements (list at least 4):

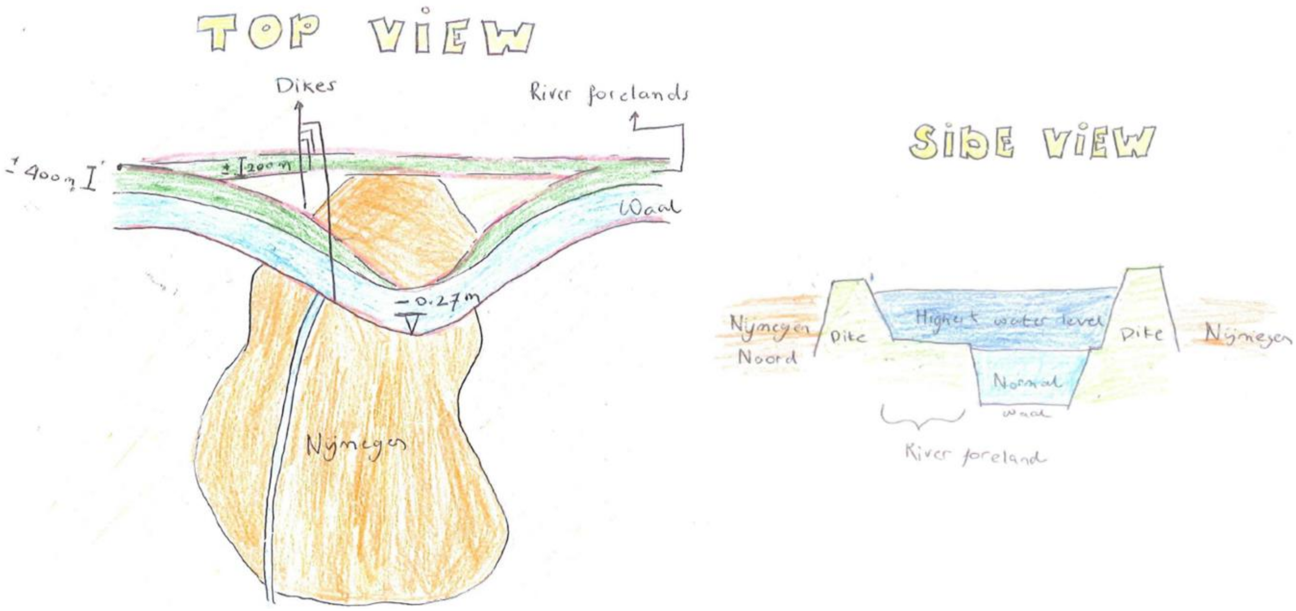
- Maintain flood protection level (1:10000)
- Improve quality of human environment
- Provide opportunities for the ecosystem
- Conservation or restoration of existing ecosystem
- Stay navigable for shipping (traffic)

Design Sketches:

Conventional solution (annotated):



BwN design (annotated sketch, indicating anticipated changes over time):



Engineering principles		Checkboxes Minimum - Maximum					Explanation
	1. Requisite standard				x		The safety standard is met at present, but most likely not in the future, because of the effects of climate change. By giving the river more room, we're able to manage higher water levels.
	2. Control variability		x				Erosion is combatted, but not totally controlled. Furthermore, after the construction the river forelands and the movement of the dikes, there aren't a lot of possibilities for control variability. If necessary, the dikes can be elevated in the future.
	3. Reasonable costs			x			Costs for the whole project, is quite expensive (especially because it has to be paid at once). On the other side, costs because of calamaties (the safe standard isn't met in the future) are much higher.
	4. Structural integrity					x	Structural integrity is accommodated by using a river forland (not a hard structure), in which the river can flow freely during high discharges.
	5. Reliability			x			There is little maintanance needed. It could be that after high discharges, the foreland need to be checked for some erosion or damages.
	6. Implementability					x	There are more than 30 Room for the River projects in the Netherlands, that's why there is a lot of experience.
	7. Adaptability					x	This design really considers the future, taking higher water levels (and room for this) in account.
	8. Resilience					x	There is more than enough space for the river to flow during high discharges. When having low discharges, everything will be back to normal and the river forelands will be free for other purposes.
	9. Appropriate boundary conditions and loads				x		A team of 19 partners (Rijkswaterstaat, water authorities, etc) has done a lot of tests to check the reliability. The prescribed Dutch boundary conditions for flood safety testing were also applied. Of course, always more conditions to test can be used.

Ecological principles	Check boxes Minimum - Maximum					Explanation
Continuity					x	In this project there is room for larger discharges to flow gradually in the river foreland, in a continous way.
No direct human disturbance			x			During low discharges, there can be people at the river foreland (on the dikes this was always the case, will be the same with this project). This can be seen as a positive development.
Indigenousness / Endogeneity			x			Uncertain which species will live in and around the Waal in the future.
Viability of populations			x			The variability of populations is still uncertain.
Opportunity for threathened species					x	There used to be only grassland along the river Waal, now there will be room and the right environment. It also priovides opportunify for species as the sand martins and kingfishers.
Trophic web integrity			x			The trophic web integrity is still uncertain.
Opportunity for ecological succession					x	The Room for the River project provides a lot of new opportunities for new ecosystem, because of the river banks and more room for vegetation.
Zone integrity					x	There is no abrupt land-water tranisition. There is a slow process, in which larger discharges can flow in the extra space around the river.
Characteristic (in)organic cycles			x			It's not known yet what will be the balance between sedimentation and erotion of the Waal at the river forelands.
Characteristic physical-chemical water quality			x			The physicl-chemical water quality is unknown. This depends on the water upstream Nijmegen, the atmosphere, etc.

	Resilience					X	The ecosystem can recover and potentially achieve a dynamic equilibrium in the river foreland.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

- Routine river monitoring: flood protection, erosion, sedimentation, navigability of Waal
- Specialized ecological monitoring (new and present species, plants)
- Monitoring of recreational use
- Safety monitoring (evacuation river foreland during high discharges)
- Monitoring water quality

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

This design is an improvement for the human environment, with new and different space for leisure activities, such as walking and biking through really special nature areas. There are all kinds of new, threatened species and plants. Furthermore, there will be a lower flood risk for the inhabitants of Nijmegen.

There are also some trade-offs that need to be made. Some of the buildings that are going to be in the river foreland, need to move, because there is a chance of flooding. Furthermore, there is an uncertainty for the ecological opportunities. It's a relatively new design method, so there aren't a lot of examples right now of Room for the River projects.

Building with Nature Design Assignment

Case Title & Location:

Fish Manager, Kornwerderzand, Afsluitdijk, Netherlands

Functional Requirements (list at least 4):

- Maintain flood safety standard.
- Ensuring freshwater supply from IJsselmeer.
- Ecological opportunities for both sea and lake.
- Safe migration path for fish.
- Increasing fish stock in IJsselmeer.

Design Sketches:

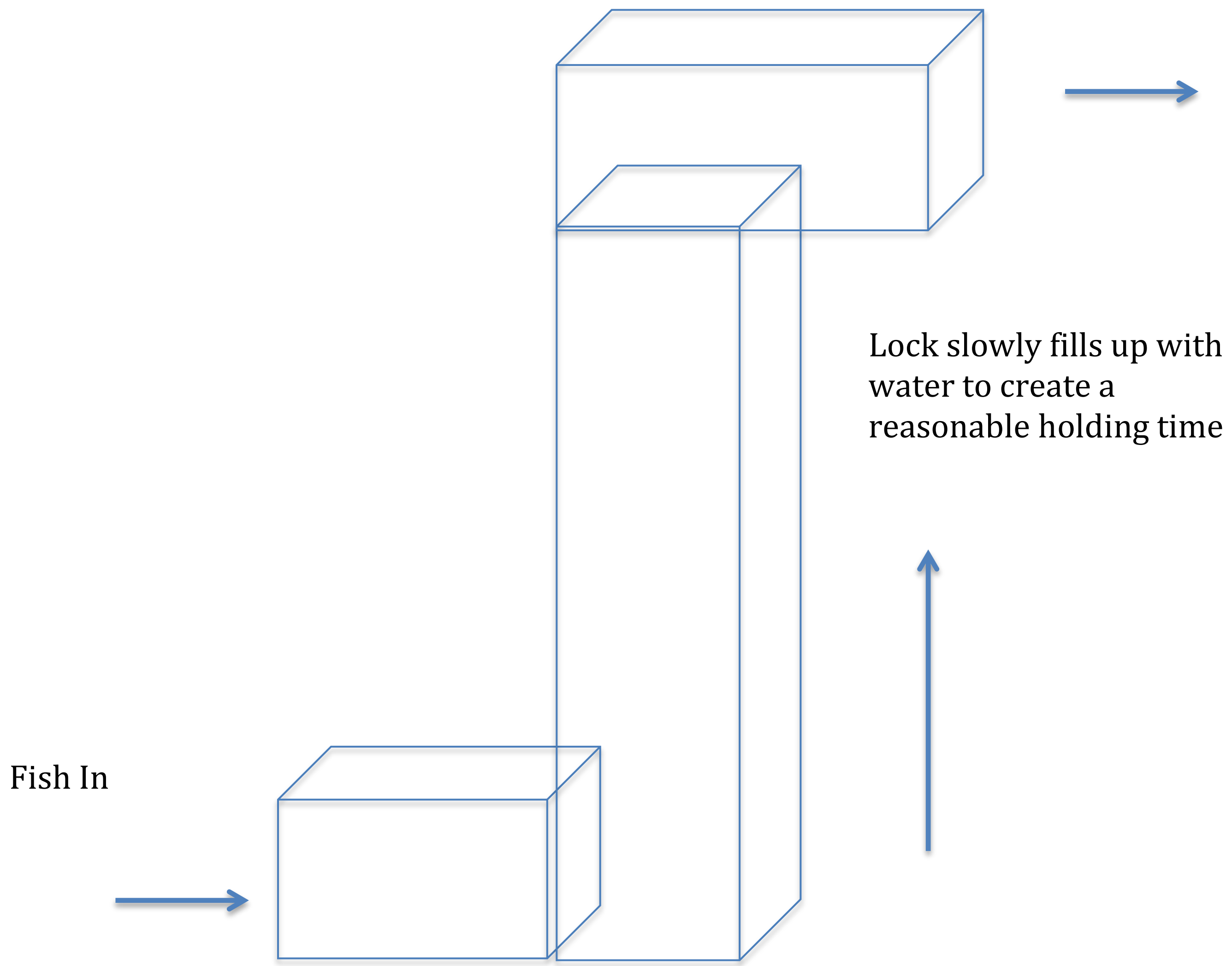
Conventional solution (annotated):
See sketch below.
Using the existing locks,, we create a lock fishway. The fish can be attracted to the lock chamber by releasing some freshwater into the sea creating attractive flows. Once enough fish have accumulated in the chamber, the chamber is closed, the level adjusted and the fish released into the lake.

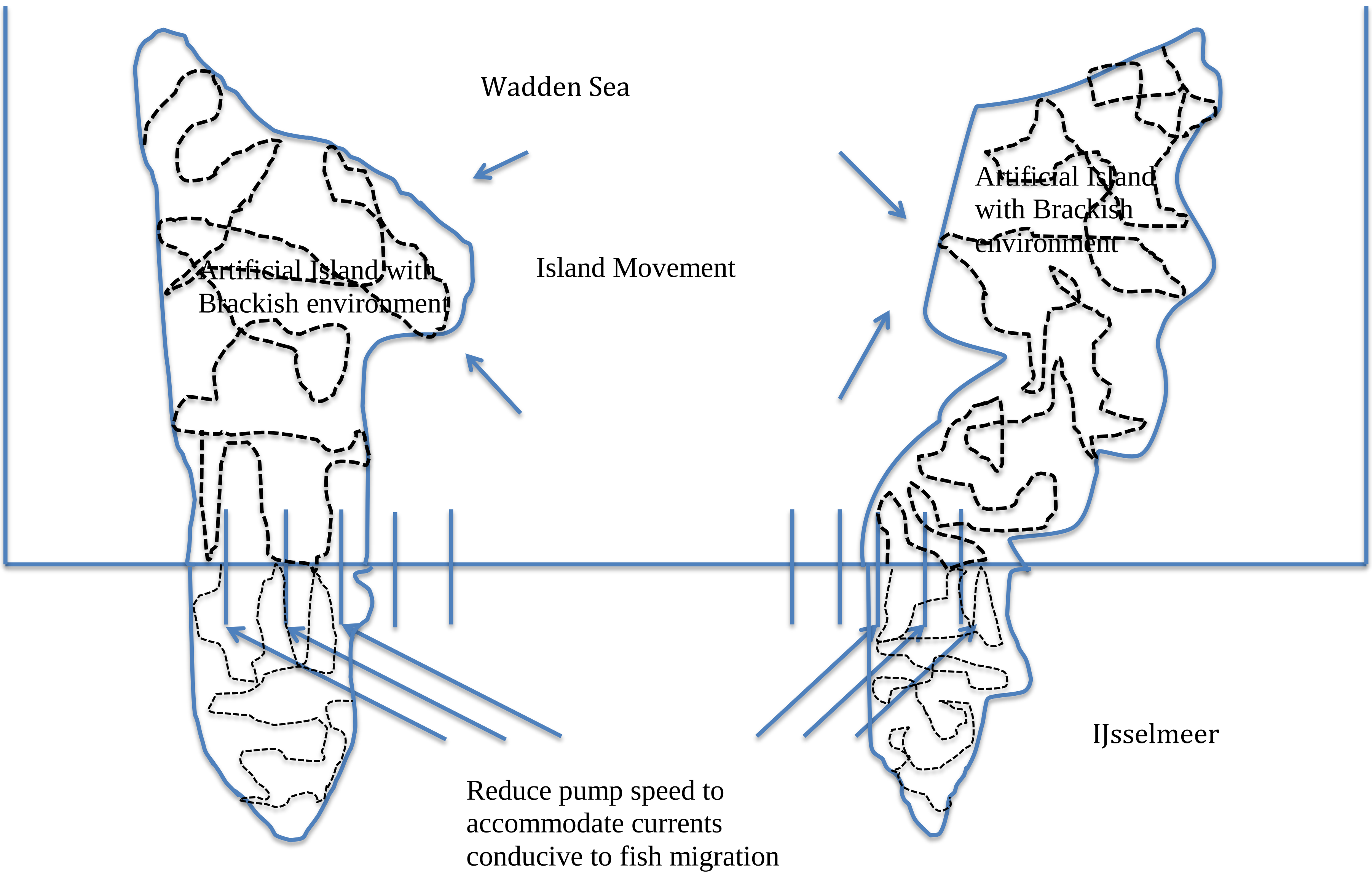
There will be a holding time in the chamber during which the salinity of the water is gradually adjusted to give the fish time to acclamatize to freshwater.

BwN design (annotated sketch, indicating anticipated changes over time):
See sketch below.

Two artificial islands, with multiple connected water ways to form brackish estuaries are created at the two sluice series. The islands encompass 3 of the sluices in both series and the pump speeds are reduced to a speed that allows the fish to migrate with ease. The heights of the islands are such that they receive sea water from the wave surges and water seepage. The position of the islands should be such that they limit the amount of sea water going over the sluices as the sluices will remain open so as to feed some sea water to the IJsselmeer side of the island to maintain the brackish environment.

The flow of water from the other sluices and the sea will eventually move the islands toward the levees but hopefully the vegetation would have established to a point to limit the movement. Any replenishment needed will be infrequent.


Fish Out
Lock slowly fills up with water to create a reasonable holding time
Fish In



Wadden Sea
Artificial Island with Brackish environment
Island Movement
Artificial Island with Brackish environment
IJsselmeer
Reduce pump speed to accommodate currents conducive to fish migration

Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles	Checkboxes Minimum - Maximum					Explanation
1. Requisite standard				x		The artificial islands are meant to absorb the force of wave impact from the sea thereby increasing the safety standard.
2. Control variability			x			The sluice speed can be controlled to bring about the desired ecological conditions but other factors are less controllable.
3. Reasonable costs		x				The creation of 2 islands and establishing the necessary conditions for sustainability will most likely be high.
4. Structural integrity					x	The amount of sand used to create the islands and the established vegetation on them ensures structural integrity.
5. Reliability				x		Some maintenance will be required on the islands in case there is more soil erosion than expected
6. Implementability					x	Artificial islands have been created in the Netherlands for a long times. There is extensive experience available. This plan is easily implemented.
7. Adaptability				x		The design takes into account that the islands might change shape although the final shape is uncertain.
8. Resilience					x	With the established ecosystem, the islands can withstand multiple floods.
9. Appropriate boundary conditions and loads					x	The boundary conditions such as flow speed from the sluices, wave movement and so on were considered.

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles	Check boxes Minimum - Maximum					Explanation
Continuity		x				The islands are divided into two by the dams although there is some continuity by water.
No direct human disturbance				x		Because of the need of period replenishment and operation of the sluices, the human element is not completely eliminated.
Indigenousness / Endogeneity			x			While the waterways are created to encourage local fish, there might also be exotic fish attracted to the new habitat.
Viability of populations					x	The whole purpose of the desigh in to create an environment conducive to the population increase of the fish.
Opportunity for threathened species					x	The islands can provided a safe haven for threathened species especially fish that need brackish water for their reproduction cycle and birds that need a resting place when migrating.
Trophic web integrity					x	The islands are designed to create an established and balanced ecosystem.
Opportunity for ecological succession					x	As time goes on, it is expected that the islands will change and become more established over time.
Zone integrity			x			Because of the dam interruption, the zone integrity is compromised.
Characteristic (in)organic cycles			x			Introducing a new ecosystem in an environment can have unexpected results to atmosphere, flora and fauna already present.
Characteristic physical-chemical water quality			x			There is no way to be certain what the final water quality will be taking into account that there are so many variables to consider.
Resilience						The islands’ design make them resilient to natural disturbances.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

It will be necessary to monitor the quality of the brackish water until it becomes constant. There is also a need to ensure that vegetation does not choke the sluices. The islands will undergo intermittent monitoring to know when they need replenishment and there will have to be a risk assessment to ensure that the fish are getting through the sluices just fine. Finally, careful monitoring of the lake is required to insure it remains fresh.

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

First of all, the building with nature sketch has nothing to do with the engineering design. As an engineer, I was looking for the quickest, cost effective and established solution. Hence, the lock fishway.

The first trade off was costs. The ecological solution cost far more than the engineering one.

The second one was control. It is impossible to control every aspect of an ecosystem. There is no way of knowing how much fish will will use the islands or what type of fish.

The third was simplicity. The lock fishway design is a simple and well established one. Its mechanism is simple and can be operated easily. The building with nature design will require multiple points of monitoring and years of study.

Building with Nature Design Assignment

Case Title & Location:

Fish Manager located near Kornwerderzand on the Afsluitdijk which connects Friesland and North Holland in the Netherlands and divides the Wadden Sea and IJsselmeer (IJssel Lake).

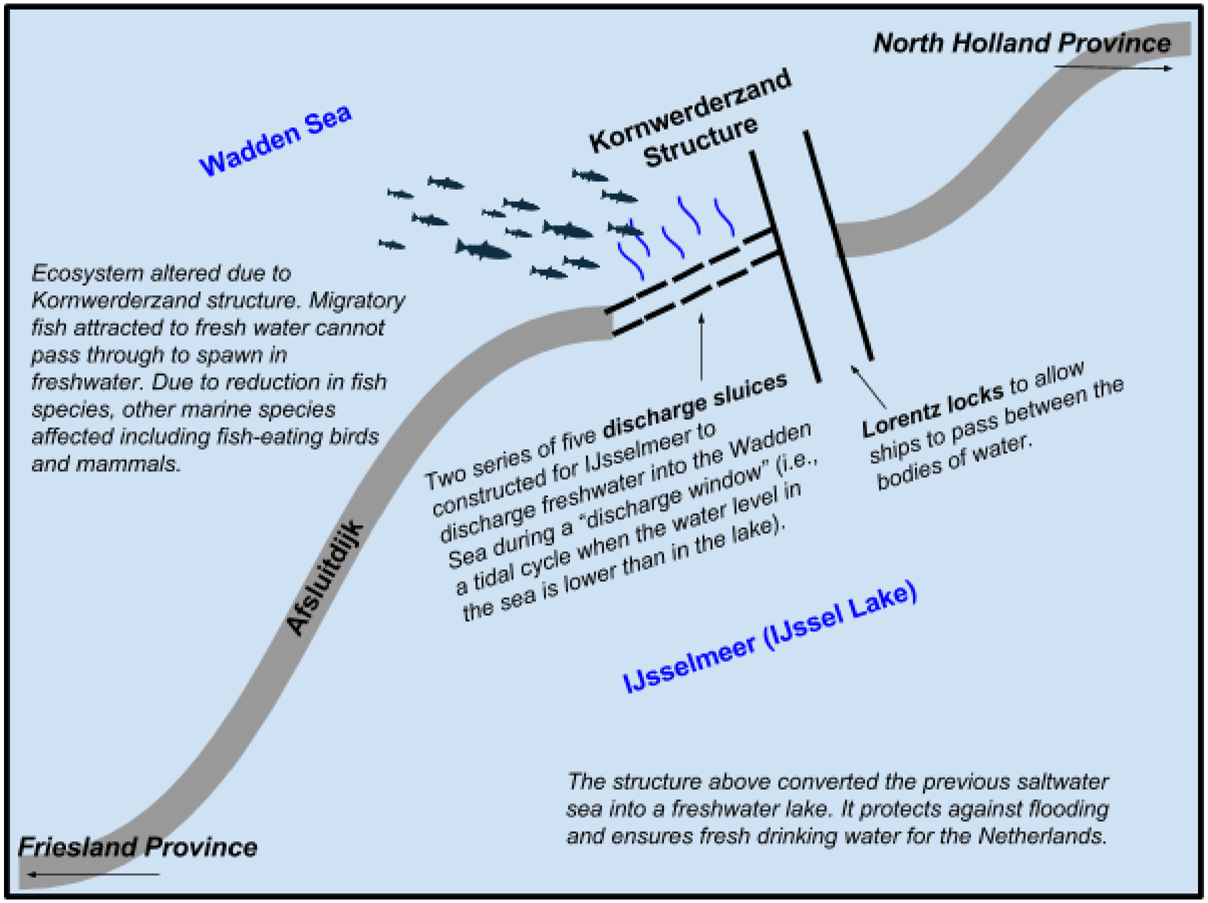
Functional Requirements:

- Maintain flood safety protection levels.
- Protect agriculture and the hinterland by preventing land erosion and flooding.
- Ensure freshwater supply from LJsselmeer.
- Restore ecosystem to include fresh-saltwater transitional areas.
- Replenish and strengthen biodiversity through the restoration of natural and dynamic estuarine processes.
- Improve commercial fishing opportunities.
- Enhance scenic and recreational opportunities.

Design Sketches:

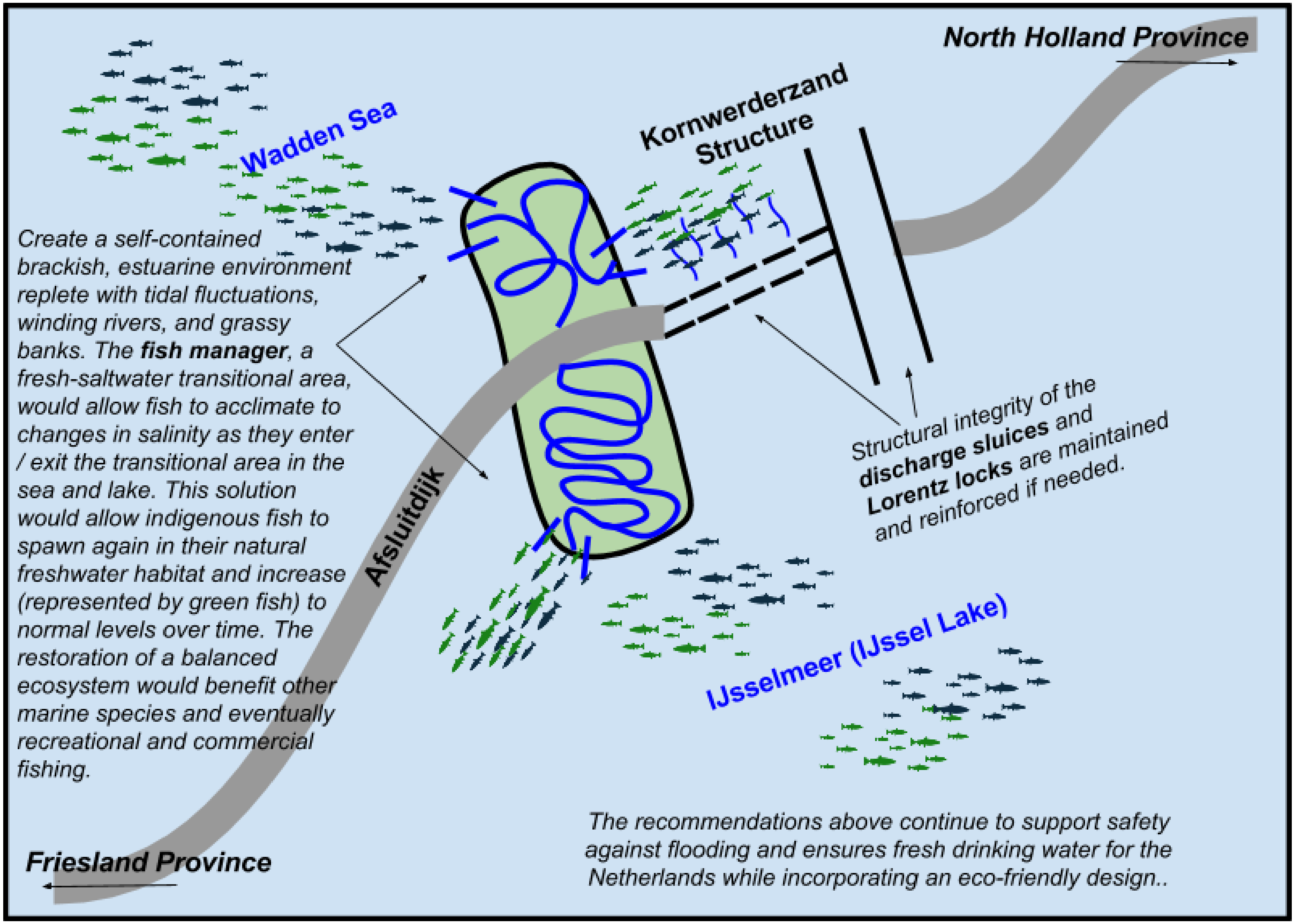
Convention solution (annotated):

Please review my interpretation / representation of Afsluitdijk's Kornwerderzand structure constructed between 1927 and 1932 (Source: https://en.wikipedia.org/wiki/Afsluitdijk).

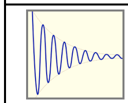
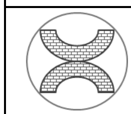
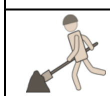
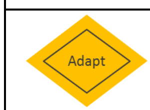


Building with Nature design (annotated sketch, indicating anticipated changes over time):

Salt-freshwater transitional area designed to restore the ecosystems marine life while maintaining flood safety standards and fresh drinking water in IJsselmeer.



Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles		Checkboxes Minimum - Maximum					Explanation
	1. Requisite standard					X	Flood safety standard and fresh drinking water are met by the current structures along the Afsluitdijk.
	2. Control variability				X		The Afsluitdijk and sluices maintain fresh drinking water. The Lorentz locks permit passage of ships between the Wadden Sea and IJsselmeer. Fish populations have declined due to alterations in the ecosystem, but the introduction the fish manager should be able to restore indigenous populations.
	3. Reasonable costs			X			Building a fresh-saltwater transitional area will require additional expenses but may be able to piggyback on overall maintenance / structural integrity of the Afsluitdijk as well as future recreational / commercial benefits of ecosystem restoration.
	4. Structural integrity					X	Plan to use natural processes to support the transitional area as well as ensure new and existing structures will not affect freshwater of IJsselmeer and flood-level standards.
	5. Reliability				X		By harnessing natural processes within the fish manager's estuarine area, I believe the transitional structure will restore the biodiversity of the region while maintaining the reliability of the current structures to prevent flooding and maintain IJsselmeer's freshwater.
	6. Implementability			X			The current sluice/lock structures have worked successfully. The fish manager appears possible but additional data is needed to determine successful implementations.
	7. Adaptability				X		Future implementations will be adjusted based on long-term results from this implementation.
	8. Resilience					X	As we have seen native fish populations attracted to the freshwater dumps from the sluices, we anticipate the ability to divert the fish to the brackish waters of the fish manager and acclimate them to varying salinity levels to encourage biodiversity growth and expansion.

	9. Appropriate boundary conditions and loads				X		Testing will be required to ensure best design for a self-contained brackish area that will permit fish to acclimate between fresh and salt waters.

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles		Check boxes Minimum - Maximum					Explanation
	Continuity				X		Creates a "pocket" into the current ecosystem to permit the re-establishment of indigenous fish in their natural spawning territories.
	No direct human disturbance				X		Some adjustments and maintenance may be required to the fish manager areas but do not expect a high-level of human traffic.
	Indigenousness / Endogeneity				X		Our aim is to re-establish indigenous fish and other marine species.
	Viability of populations				X		Offering the opportunity to increase the population species. This will need to be evaluated over time.
	Opportunity for threatened species			X			Offering the opportunity to increase the population species. Through evaluation, will need to determine if the ability to restore threatened species is possible.
	Trophic web integrity			X			The fish manager design aims towards maintaining appropriate levels to support the needs of the indigenous species entering the transitional region. Will need to evaluate whether the transitional area can maintain appropriate trophic levels.
	Opportunity for ecological succession				X		The aim is the restore the balance of indigenous species. It's been many decades, however, and there may be opportunities for new ecological successes. This will need to be measured / evaluated over time.
	Zone integrity			X			The fish manager design aims to ensure zonal integrity / provide less disruption to ecological processes. Evaluation will determine the ability to maintain zone integrity.

	Characteristic (in)organic cycles			X			The aim is to ensure the integrity of the ecosystem. Will need to measure / evaluate this over time.
	Characteristic physical-chemical water quality			X			The fish manager design amils to ensure the brackish, tidal environment are maintained. Will need to evaluate the characteristics of the estuary over time.
	Resilience				X		As we have seen native fish populations attracted to the freshwater dumps from the sluices, we anticipate the ability to divert the fish to the brackish waters of the fish manager and acclimate them to varying salinity levels to encourage biodiversity growth and expansion.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

- Functional requirements for flood safety and fresh drinking water are addressed via the current infrastructure.
- Monitor current as well as any new structures to ensure adherence to standards.
- Ecological and biodiversity requirements will require monitoring and evaluation over a period of time. Will need to determine if the new fish manager supports its expected vision and goals.
- Recreational and commercial requirements will also require monitoring and evaluation. Until native fish reach an adequate level of sustainability, recreational and commercial fishing should be limited.

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

- Balance complex funding strategy to support transitional fresh-saltwater areas like the fish manager.
- Building with Nature does not guarantee absolute certainty / positive outcomes. Results, for example, may support a smaller biodiverse population than in previous habitat..
- May see indirect benefits of the new estuary due to shifts in zone and web trophic integrity levels.
- Potential Introduction of non-indigenous species that survive in the new order of “things” to support new habitat as well as recreational and commercial needs.

Building with Nature Design Assignment

Case Title & Location:

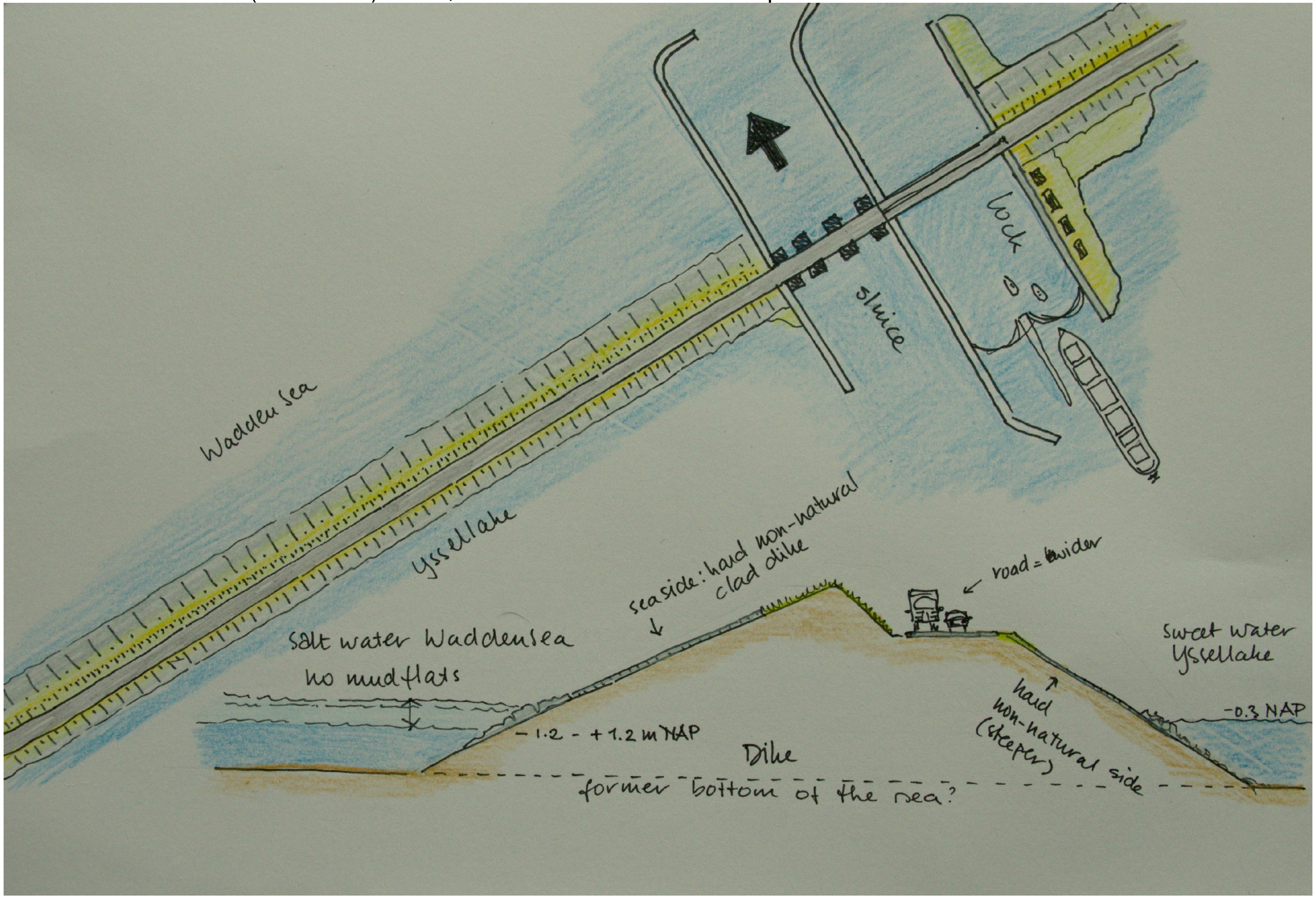
Fish manager, Afsluitdijk

Functional Requirements (list at least 4):

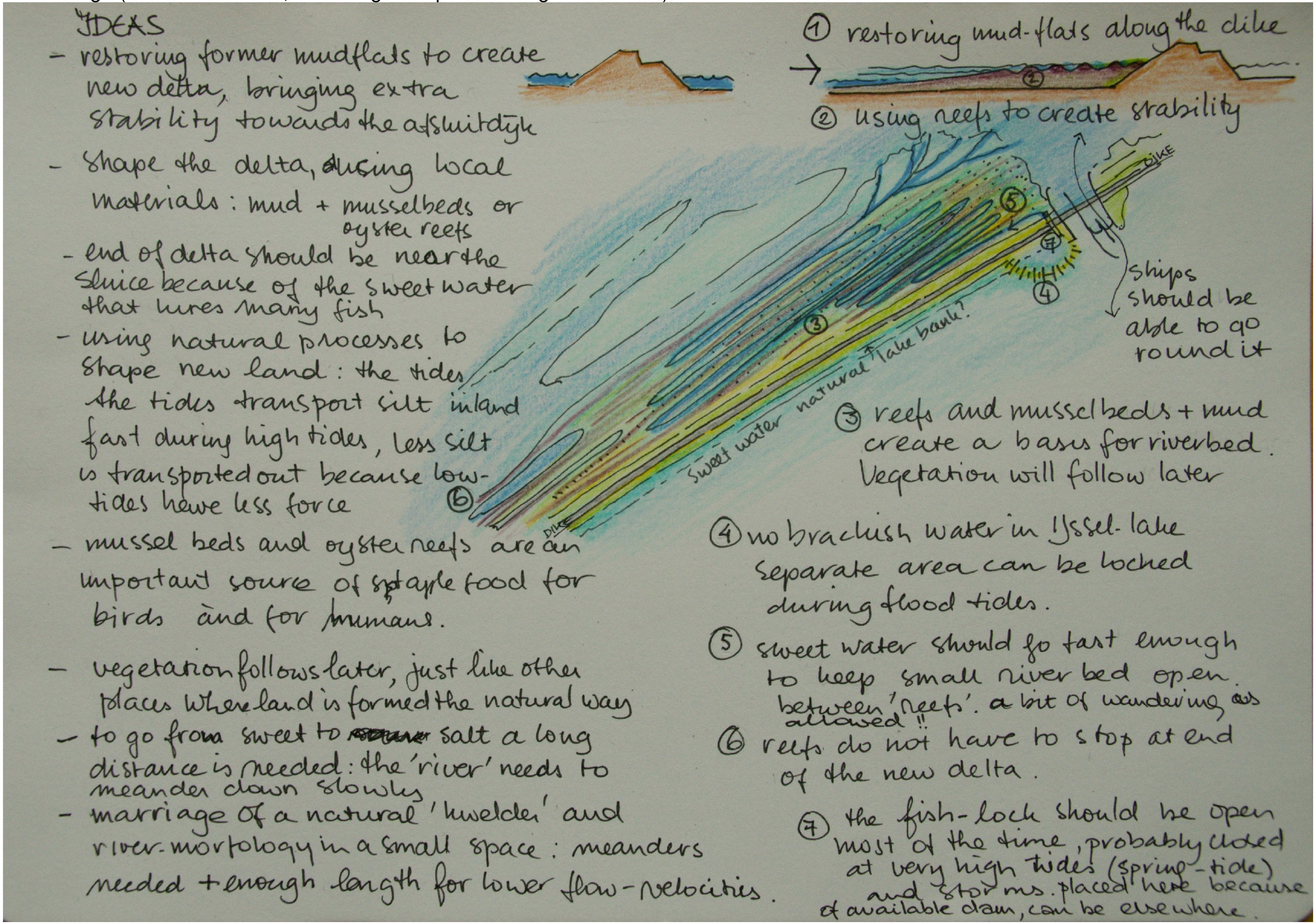
- The flood protection for the land near the IJsselmeer (IJssellake) area must be maintained
- The freshwater-reservoir function of the IJsselmeer must be maintained
- The sluices and traffic (sea and land) must be maintained
- Restoring an ecological connection between the Wadden Sea and IJsselmeer region
- Realising a more gradual transition between sweet and salt water
- Giving people a chance to see the fish migrating

Design Sketches:

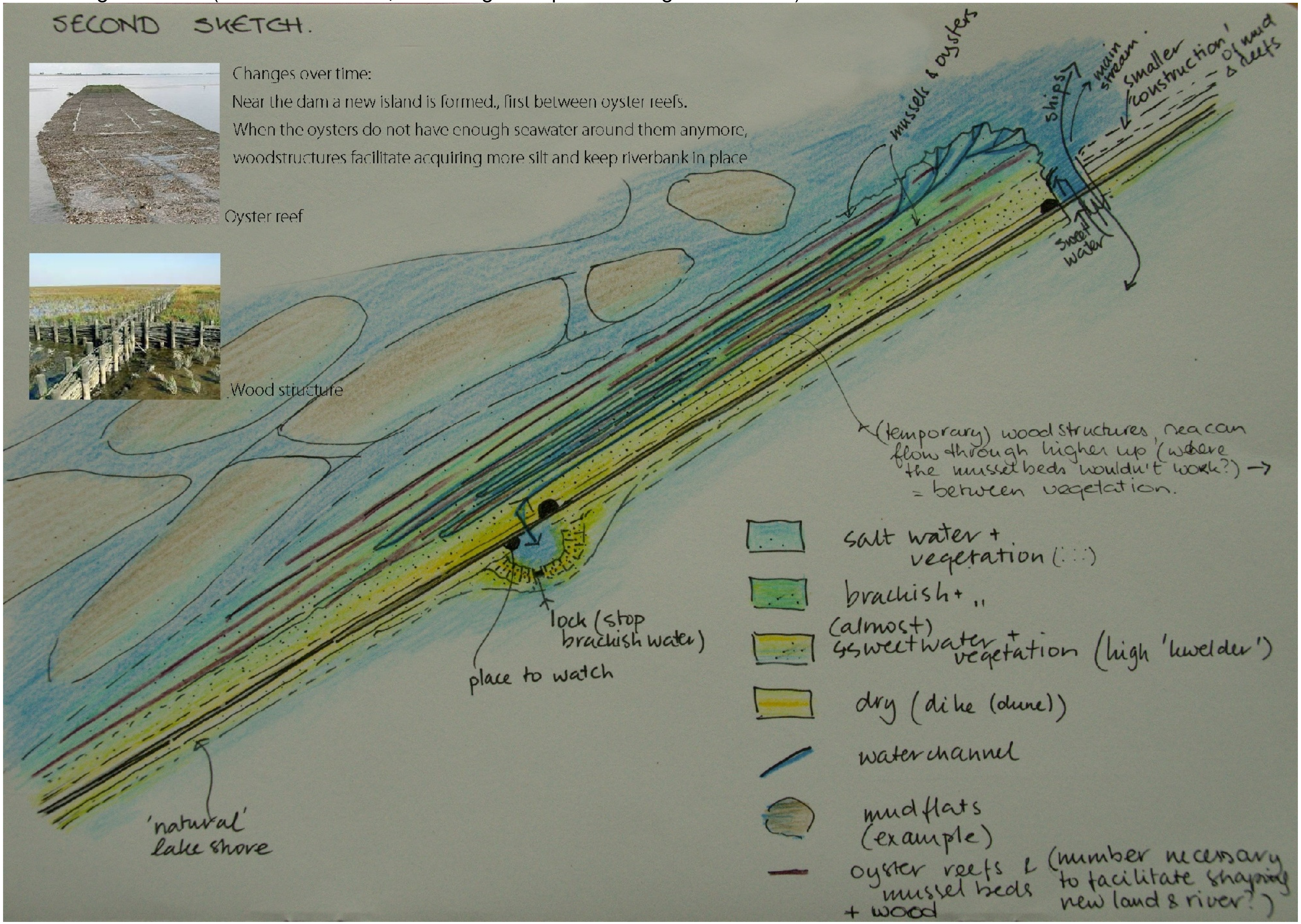
Conventional solution (annotated): Dam, difficult structure for fish to pass



BwN design (annotated sketch, indicating anticipated changes over time): “Kwelderdelta”

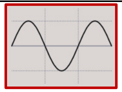


BwN design PART II (annotated sketch, indicating anticipated changes over time):



Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles	**Checkboxes** Minimum - Maximum					**Explanation**
1. Requisite standard				x		Flood protection and sweet water reservoir are the main reasons for the building and maintaining of the Afsluitdijk. The hight of the afsluitdijk, and the stability stay the same. New element is the fish lock, essentially a hole in the dike that must be controlled and guarded. There are two protection systems: the fish lock door and the lock to stop brackish water.
2. Control variability			x			Some variability in the location of the riverbed because of the silt deposit. Variability in water is controled in the fish lock in the dike (springtide) and there is a lock to precent brackish water from streaming in. Variability in the river channel and the silt depositing is not controlled.
3. Reasonable costs			x			No idea, but it is a large operation, Though it is made by just placing oysterreefs en musselbeds, later wood structures, and slowly letting the sea assist in letting silt accumulate, it might be feasible!
4. Structural integrity			x			Downside: Question marks about the main currents and tide currents in the Waddensea. They might differ from more northers locations in the waddensea, where kwelders are formed. Upside: extra stability for the dike, because of the wave breaking fore land. The structural integrity of the dike itself is not threatened, provided the fish lock closes well during storms and spring tide.
5. Reliability				x		Natural silt layering between the oysterbanks is reliable in Zeeland, where a part of the coast is protected by reefs.Mussel beds are abundant in the area. It should be reliable in existence. Variability and monitoring (plus maintenance) expected around the fish river channel.
6. Implementability				x		Oyster reefs and mussel beds are relatively new, but tested methods in the Netherlands. The wood structures are ages old, used to gain land since the Middle ages. Maintenance of the fish river channel might be difficult, depending on currents and structure. In short: to be investigated..
7. Adaptability					x	High: reefs and beds, wood structures can be changed easily, adapted when needed. When water levels get higher in the future: silt will be deposited higher too.

	8. Resilience				x		Because of the natural silt accumulation, more resilience in the future is expected. The structure of the dike is not altered. Good and extended maintenance of “fish lock”
	9. Appropriate boundary conditions and loads			x			Because of the question marks about the main currents and other environmental conditions, I don’t know if the right boundary conditions are used.

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles	**Check boxes** Minimum - Maximum					**Explanation**
Continuity					x	More continuous flow from salt to sweet for fish
No direct human disturbance			x			Some disturbance by ecotourism: people can watch it from several places, and maybe even walks are organised.
Indigenousness / Endogeneity			x			Oysterreefs also contain japanese oysters, so there is a danger of extra growing places for this new species. All other growing places are natural for the Waddensea
Viability of populations					x	Fish populations will prosper Oyster en Mussels populations too, as for salt tolerant vegetation
Opportunity for threathened species					x	Threatened fish species get an extra boost.
Trophic web integrity					x	By introducing more staple food for birds and mammals, trophic integrity goes up
Opportunity for ecological succession					x	Between the reefs there is a possibility of ecological succession from salt to sweet water "kwelders", with their natural vegetation
Zone integrity					x	New zones with natural gradient from salt to sweet are formed along the dike
Characteristic (in)organic cycles			x			I don't know
Characteristic physical-chemical water quality					x	The transition from sweet to salt: every low tide experienced, fish will be able to swim upwards
Resilience			x			Higher variation in vegetation and water depths along the dike will give a more resilient ecosystem in general. The flood channel might be overgrown or moving in areas, than continuity for fish might stop.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

The fish lock should be checked regularly

Monitoring is necessary for the fish channel: it should be controlled regularly. It is allowed to alter itself, or to move, but accessibility for fish should be maintained.

Also I expect some monitoring of oyster reefs and mussel beds will be necessary. They can be renewed outwards if necessary. Higher up wood structures may help to get more silt in, and gain a high kwelder.

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

Eco <-> safety
The main trade off is between a totally closed dike, and a dike with a small hole in it, to let the fish enter the lake. This is made possible by adding extra safety measures: a fish lock with a door to close in times of high tides.
Enough safety measures against an ecological plus, I considered a plus

Eco <-> safety
The sweet water reservoir of the Ijsselmeer should be maintained, but is slightly smaller because with the fish lock brackish water can enter during higher tides.
Only a small brackish water lake is added and combined with a lock to prevent brackish water from entering in the lake, when letting fish in. Is regarded as less safe than total closure, but probable.

Eco water <-> eco mud flat and kwelder
A second trade-off is between two types of habitat. Introducing extra kwelder reduces the water area in the waddensea. It adds however an area with slow gradients to a hard unnatural surface, which I considered a plus.

Less space for water recreation <-> new habitat to watch birds and migrating fish: both recreationary values. Provided ships can still reach the Waddensea at Workum: this is OK

Building with Nature Design Assignment

Case Title & Location:

Hondsbossche Pettermer Zeewing between Camperduin and Petten. North Holland Coast

Functional Requirements (list at least 4):

- Being able to withstand a storm surge with an incidence occurrence of 1 in 10000 years (the Dutch flood protection standard)
- Protection of the coastal area in an efficient manner
- Resistance of erosion, conserving or even restoring the natural environment in this stretch of the coast through a nature friendly solution
- Provide opportunities for nature to thrive
- Increase the recreational space and its quality along the North Holland Coast

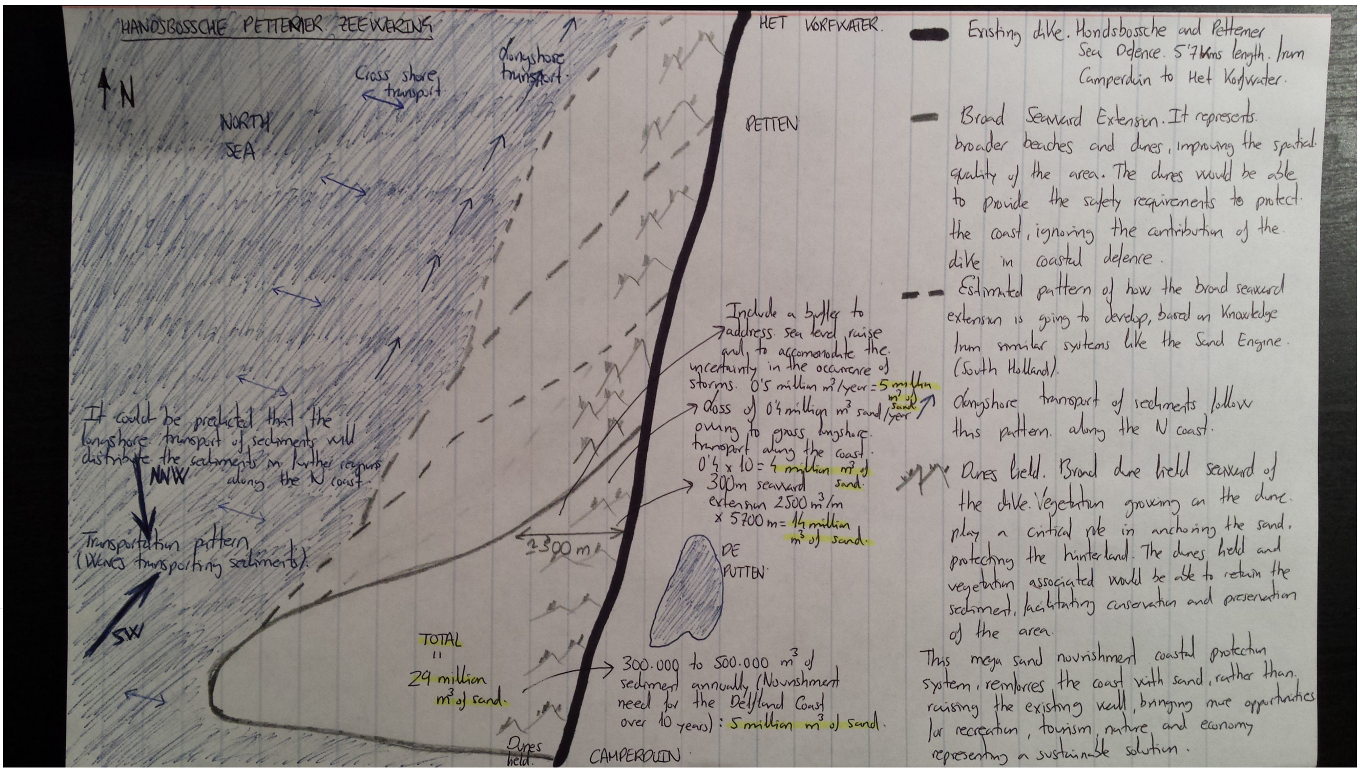
Design Sketches:

Conventional solution (annotated):

This stretch of the North Holland Coast, between Camperduin and Petten, has been relied on a massive dike to protect the coast along the years.
The coastal defense used to be 2 separate dikes, but over time they have been upgraded to one contiguous sea defense structure (Hondsbossche and Pettermer Sea Defence)
It is 5 km long, and the dike was first developed in 1421 after the Sint-Elizabeth flood. Since then, work has been carried out along the dike to reinforce the protection of the coast, although it has come to a point where restoration of the dike is not longer appropriate.

A recent study has determined that the dike does not satisfy safety requirements over the next 50 years, therefore a different approach to combat erosion in a nature friendly manner is developed

BwN design (annotated sketch, indicating anticipated changes over time):



Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles	Checkboxes					Explanation
	Minimum - Maximum					
1. Requisite standard					X	It represents a solution for coastal protection, restoration and conservation in the long run, increasing safety against flooding in the region. It would be able to withstand all the conditions for which it is has been built, withstanding severe storms
2. Control variability			X			Control of coastal erosion is implemented through this strategy, although it is inconclusive how well it is going to work to protect the coast, as it is based on model studies and predictions
3. Reasonable costs		X				The cost could be quite substantial, although looking in the long run, how well it is predicted it is going to protect the coast, and the social-sport activities that the nourishment of the coast is going to bring to the area, it might be worthy
4. Structural integrity					X	Natural sand body to protect the coast. The sand nourishment of this region is fully balanced and integrated with its environment, creating a dynamic natural environment to protect the coast and meeting its functional requirements
5. Reliability					X	The project relies in the used of natural materials and dynamic natural processes with minor and easy maintenance, being reliability very characteristic in this project
6. Implementability				X		It is feasible, considering improvement along this stretch of the coast in the long run. In terms of how reasonable it is to build and maintain, considering that there is some experience through similar projects (The Sand Engine), the score is high
7. Adaptability					X	The main characteristic of this project is the adaptability, as it has been thought to provide improvements along this coastal region in the long run, no maintenance dredging would be allowed within the first 10 years. Long term vision over the next 50 years
8. Resilience					X	It will be able to withstand strong storms, battling out these events, with the benefits of the dynamic environment of this project, being able to withstand repetitive storms over time and continuing to meet ifs functional requirements
9. Appropriate boundary conditions and loads				X		It is a project relatively new, based on predictions and model designs, although some experience has been gained through previous similar large scale beach nourishments. Monitor of the project is needed over time

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles	**Check boxes** Minimum - Maximum					**Explanation**
Continuity					X	The project enhances water and sediment flow, providing more gradual transitions between land and water, therefore continuity is very high
No direct human disturbance					X	The project consists on no maintenance nourishment of this coastal region within a 10 years period after construction, no recurrent sand nourishment minimize human disturbance
Indigenousness / Endogeneity			X			It is uncertain which species (exotic or indigenous) will colonize new biotopes
Viability of populations			X			It is unclear at this moment to establish this principle, although based on similar projects done in the past, the perspective is highly positive, although based on monitoring
Opportunity for threathened species				X		Opportunities are created for their survival and restoration. New habitats are created restoring connectivity and improving circulation
Trophic web integrity			X			All levels and species should be interacting in a healthy way, with strong presence of keystone species, although it is uncertain and requires monitoring
Opportunity for ecological succession					X	This system facilitates the emergence of pioneer ecosystems stages, giving opportunities for dynamic changes, which are crucial for ecosystems
Zone integrity					X	Uninterrupted natural processes throughout this system, facilitating water and sediment flow fulfill this principle
Characteristic (in)organic cycles			X			It is uncertain at this moment to evaluate this principle, as it is based on, how the sand from the seabed on the Dutch continental shelf is going to interact with the environment
Characteristic physical-chemical water quality			X			Similar to the principle 9, there is uncertain, as still unknown how it is going to interact with the environment. Ongoing monitoring is required
Resilience					X	The ecosystem can recover and can potentially achieve dynamic equilibrium

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

The North Holland Coast is an environment with natural existence of dunes and strong influence of the wind and waves. The system proposed through mega sand nourishment as coastal protection, with broad seaward extension has a long term vision, over the next 50 years, without dike heightened, bringing more opportunities for recreation, tourism, nature and economy,.
Therefore it represents a sustainable solution where the ecosystem establish itself in order to thrive.
This ecosystem should facilitate the conservation and preservation of the lagoons, like “De Putte” and also the ones further North like “Nordzee and Zwanenwater”
Monitoring is required in terms of ecological risks, like potential colonization by invasive species, water quality and engineering risks, such as the sand moving northwards or offshore at a greater rate than expected.
Therefore monitoring is crucial to provide early warning signs of undesirable developments and allow risk mitigation

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

The project involves trade-offs. Even though the reasonable cost might be high, it is important to take into consideration that this project has a long term vision, being able to provide protection of the coast over the next 50 years.

There are also many parties involved in the project, like the Dutch Ministry, the district water board, the province of Noor-Holland, local residents, entreprenaurs, nature lovers, recreant, tourist and the nuclear facility.,
Therefore the finace of the project would be viable by coalition of stakeholders.

The main benefits of the project are the reduction of distrubance, in terms of there is not need for maintenance nourishment of this coastal region over 10 year period after construction, allowing the ecosystem to establish itself, and the opportunity for new habitat formation. It also creates a coastal protection system against very severe storms and flooding while also bringing more opportunities for recreation, nature and economy throughout a sustainable strategy.

Even though ecological opportunites are an important feeature of this system, regular monitoring is very important in relation to some uncertainities established in the ecological principles.

Building with Nature Design Assignment

Case Title & Location:

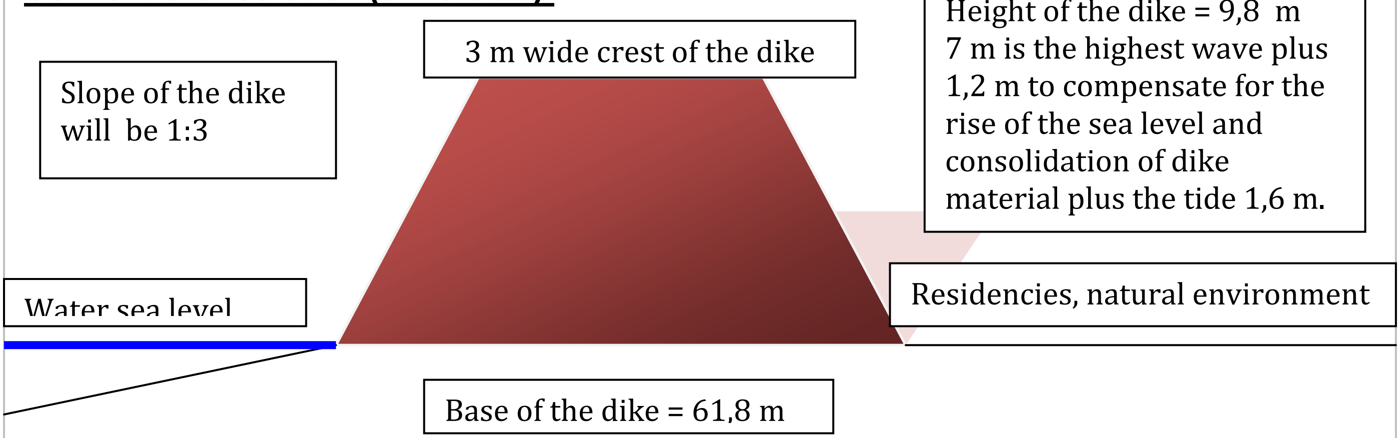
Coastal Protection between Camperduin and Petten in North Netherlands

Functional Requirements (list at least 4):

- Flood protection of hinterland, nuclear plant, residents
- Flood protection of the nature area behind dune
- Create recreation space
- Protect farms and grassland for cattle
- The solution has to protect the environment and be cost-effective
- The solution must have the agreement of the client, residents and nature organisations.

Design Sketches:

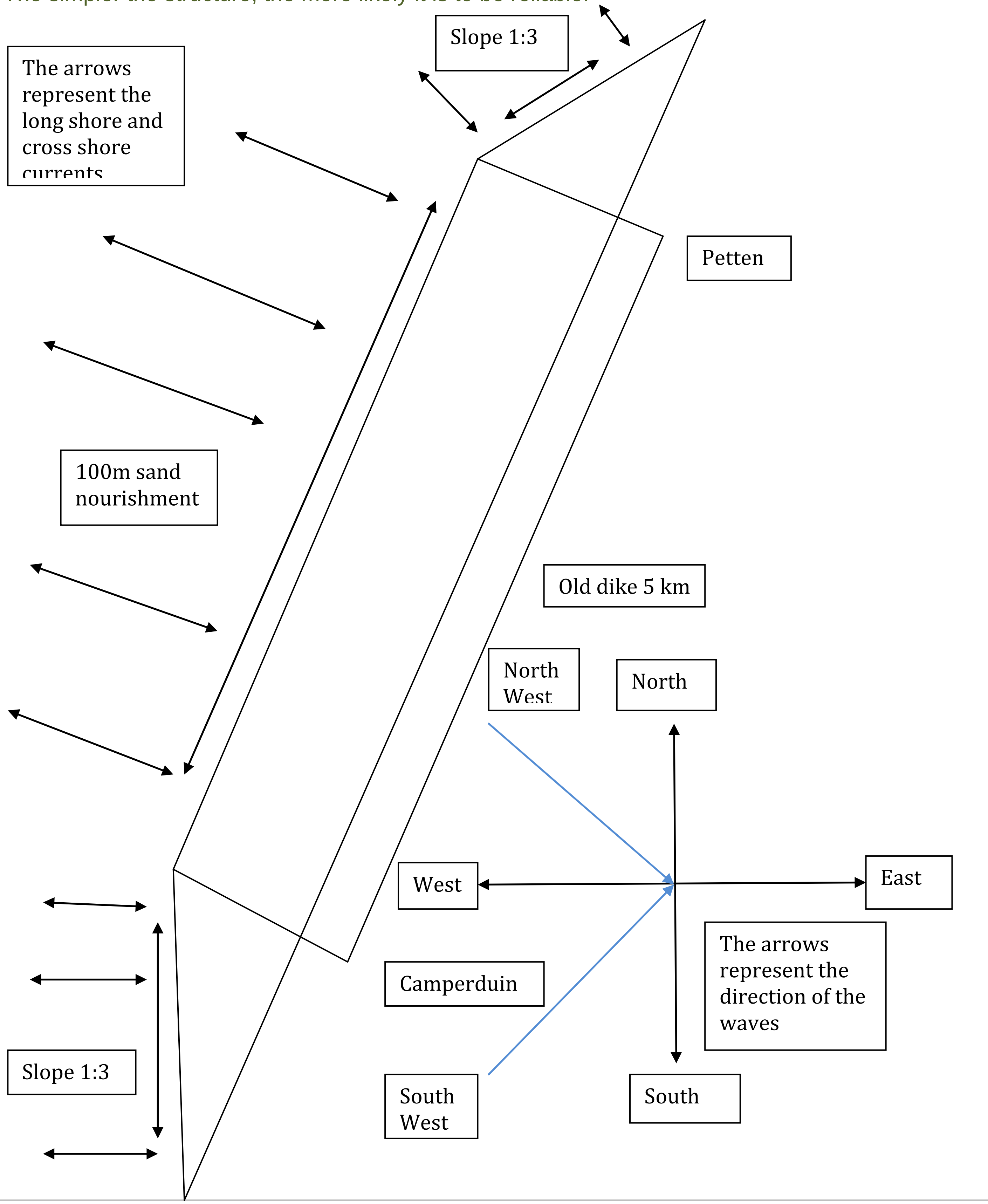
Conventional solution (annotated):



As I have seen in pictures from the Hondsbossche Zeewering, the dike is very close to the beach foreshore, which means that the force of the waves dissipates almost entirely on the dike. This means that the dike is subjected to wave erosion. The width of the beach on the seaward side in front of the dike is very small. Also it is clear from the photographs of the area that the groynes could not collect sufficient amount of sand travelling alongshore in order to broaden the width of the beach and apparently dissipate more wave energy. Heightening and broadening the dike means that the contractor has to mobilize equipment to work both to the internal and external side of the dike. Equipment working on the external side must operate in a limited area as it appears on the pictures from site, equipment work on the internal side will find difficulty due to the presence of the lake and the preserved area and also the city (the equipment will cause disturbance to residents). It is mentioned throughout the course that this operation is not cost-effective. The spatial quality of this area will detreriorate if heightening and broadening is used because valuable space will be transformed to dike strengthening. Dut to the presence of the dike there is no room for recreation of residents and tourists on the seaward side and a berm has to be constructed on the seaward side so the space will deteriorate more. As it appears from photographs the internal side of the dike is vegetated, this restricts the amount of water overtopping the dike to only 1lt/meter/second (Engineering Design Process Video). So the dike has to be strengthened also on the internal side to reach probably overtopping amount of water at 200lt/meter /second.
The strength of the core of the old dike has to be investgated (more funding).

BwN design (annotated sketch, indicating anticipated changes over time) :

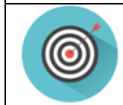
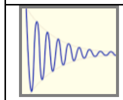
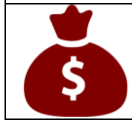
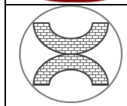
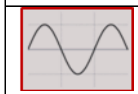
The simpler the structure, the more likely it is to be reliable.



14500000 cubic meters of sand nourishment

The BwN proposal consists of a 100m extension seaward with sand coming form the seabed of the North Sea. The sand will be extracted from areas proposed from the Dutch Ministry of Infrastructure and Environment. The sand will be placed to the areas of interest with the method of rainbowing (Palm Island construction, Artificial Island Between Sweeden and Denmark construction), because through this method the clay and silt sediments which are lighter than the sand can be carried away through current transportation, leaving behind the sand which is a good soil for shore protection. Since the method of sand nourishment is still under consideration, it is preffered to create a 100m sand beach rather than a 300m beach (greater cost), monitor the results from the solution and move ahead with this solution at small steps carefully. Broad seaward extension can lead to huge loss of sand through cross wave processes and the transportation of sand to deeper water. The main sand nourishment will be formed from **5000000 cubic meters** of sand spreaded over the length of 5 km plus **5000000 cubic meters** of sand spreaded on the same area compensating for the uncertainty of severe storm surges plus **500000 cubic meters** of sand compensating for the loss of sand due to cross shore currents. The sand will placed uniformly over the entire area of interest creating a smooth beach profile, able to break waves. On the north side and on the south side of the nourishment **4000000 cubic meters** of sand will be placed compensating for the long shore transport of sediment. The inclination of this transitional nourishments with the beach will be 1 : 3 to facilitate the current movement and to prevent loss of sand. The design is based on the assumption that due to the presence of northwest and southwest waves the loss of sand from longshore transport will not be as much as it would be due to currents movement in one direction. The groynes already existing will remain under the beach nourishment adding to the stability of the protection system. The existing dike will remain (remoaval of the dike will be an added cost to the project) to serve as a last defense system in the case of a severe storm surge. It is imperative to protect the HMS Prince George Wreck (historical monument) with the construction of a dike on the beach nourishment, surrounding the wreck and make it accessible to residents and tourists. It will be in the side of safety to create salt marshes with indigenous plants on the width of the beach nourishment to use them as erosion control plantings (transplants must be used, no seeds), the salt marshes (wetland) will dissipate the wave energy and prevent high winds from transporting the sand. The salt marshes will act as nesting place for birds, and through the process of ecological succession will make the nourishment more ecological fiendly and stable(the roots of the plants and trees keep the sand in place).

Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles		**Checkboxes** Minimum - Maximum					**Explanation**
	1. Requisite standard					X	It must withstand the severe storm that will occur once in 10000 years.
	2. Control variability					X	The sand nourishment will control the fluctuation of the wave height and sea currents.
	3. Reasonable costs					X	It is a simple, cost effective solution.
	4. Structural integrity				X		It is a simple solution, following natural processes. We imitate nature to protect the shoreline. Yet needs monitoring.
	5. Reliability				X		It is a new solution, needs thorough monitoring, but since we follow natural processes, this makes the solution reliable.
	6. Implementability					X	It is easy to construct (dredging equipment, land surveyors). No disturbance to local communities, all the work is done offshore.
	7. Adaptability					X	The sand nourishment through wave movement can easily adapt to changes. It is this feature of elasticity that helps absorb efficiently the wave energy.
	8. Resilience					X	The sand will move offshore through winter on onshore through summer with a loss of sand to deep water. This is a cycle of sand movement (resilient).
	9. Appropriate boundary conditions and loads					X	It is an engineering environmental friendly project that must control wave action and beach erosion at feasible cost.

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles	**Check boxes** Minimum - Maximum					**Explanation**
Continuity				X		The flow of water and sediment is not restricted, just controlled.
No direct human disturbance			X			It is a man made project, but with respect to nature.
Indigenousness / Endogeneity				X		Sand from the seabed of the North Sea will be placed on the beach. There is no apparent danger of exotic species intruding in the environment.
Viability of populations				X		Populations which live onshore will be disturbed during construction, but because it is designed to let the nourishment undisturbed for the next 10 years, the populations will have the opportunity to recover.
Opportunity for threathened species					X	The new broad beach that will be created will be a shelter for fauna and flora, instead of the limited space existed due to the presence of the dike.
Trophic web integrity				X		The trophic zone integrity will be disturbed at the beginning, but since this is a nature friendly project, it will possibly recover.
Opportunity for ecological succession				X		If the sand nourishment is planted with indigenous plants the ecological succession will be triggered.
Zone integrity				X		There will be disturbance to the onshore zone, but in a 10 year period will probably recover.
Characteristic (in)organic cycles				X		The throughputs will be disrupted due to the construction, but it is highly possible to recover after 10 years of no disturbance.
Characteristic physical-chemical water quality				X		The physical chemical water quality will change (more beach to dissipate rain water), but this will not probably be a great side-effect.
Resilience					X	The resilience of the ecosystem will be under pressure during the construction of the project, but it is most likely to withstand.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

Fish population has to be monitored prior and after the construction of the project. Water quality has to be chemically analyzed. The time when the project will start is crucial, because it is important not to disturb fish population through their reproductive season. Sand to be placed on the beach must have preferably the same particle size and chemical composites like the sand existing on the beach.

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

The BwN sketch will disturb for a short period of time the ecosystem : water quality will change, new sand may have different particle size or different amount of silt and clay from the existing sand, this is bad for the fauna finding food in the sand, the zone integrity will also be affected for a short period of time, fish populations might migrate until the new placed sand settles, creating a steady environment, but it is accepted that through this procedure the environment will find its equilibrium state quickly. A place for flora to thrive will be created in front of the old dike through sand nourishment, recreational room is created, the seaward expansion prevents the hinterland expansion of flood protection (valuable farms, grassland for cattle, residencies). The BwN solution is cost effective and more cheap than the old method of building dikes. Aesthetics also plays an important role, it is much more beautiful to have a long beach rather than a tall dike hiding the horizon. Reliability is guaranteed since it is a simple project taking advantage of natural dynamic processes for wave energy dissipation, it is a nature tested design.

Building with Nature Design Assignment

Case Title & Location:

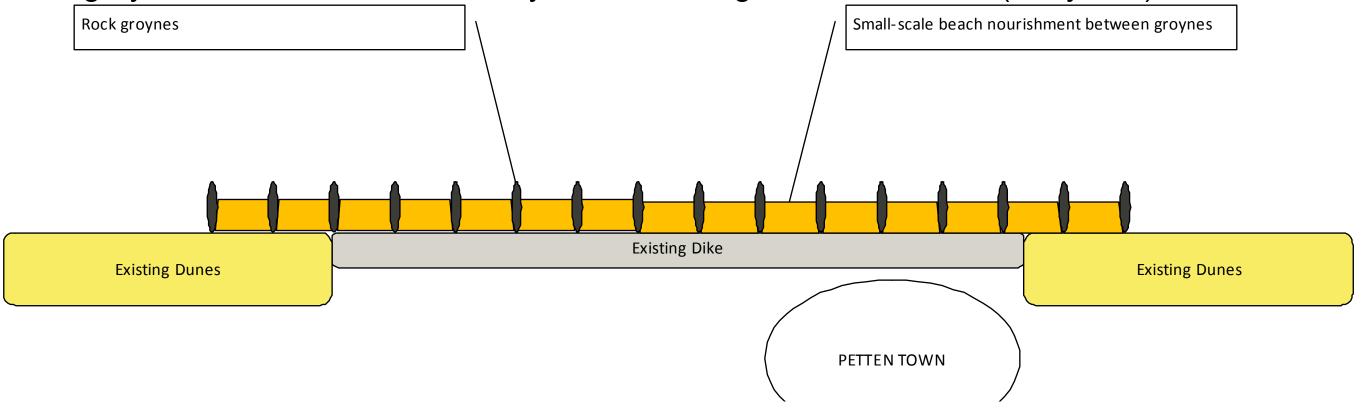
Hondsbossche and Pettemer Sea Defence, North Holland

Functional Requirements (list at least 4):

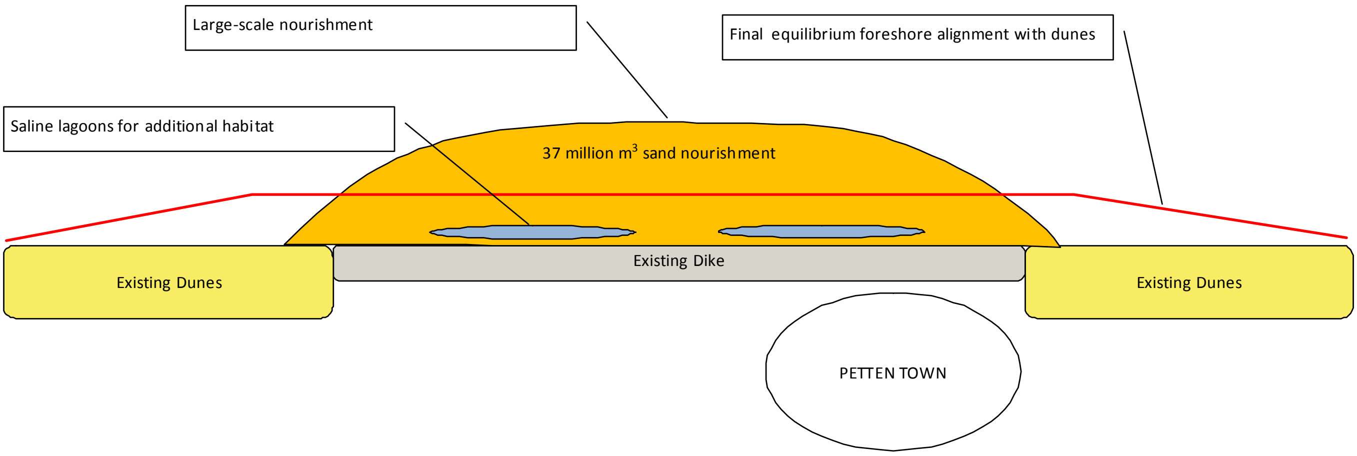
- Coastal defence against a 1 in 10 ,000 year storm
- Adaptability: minimum 50 years sea level rise
- Reliability: low requirement for intervention (limited maintenance to support ecological resilience requirement)
- Ecological Resilience: Minimum of 10 years between nourishment interventions
- Enhanced tourism: more space for leisure activities

Design Sketches:

Conventional solution (annotated):
Rock groynes and small beach embayments with regular nourishment (3-5 years)



BwN design (annotated sketch, indicating anticipated changes over time):
Large-scale nourishment on shorefront of 37 million m^3. This is centred on the existing dike rather than in a hook shape to ensure the entire historic dike is improved simultaneously. Further nourishments of 4.5 million m^3 would be needed every 10 years over the design life.



Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles	Checkboxes Minimum - Maximum					Explanation
1. Requisite standard					X	Volume of beach material has been calculated to provide a beach cross-section which will meet the 1 in 10000 storm level.
2. Control variability		X				Natural processes are being used to combat erosion rather than control it (a traditionalo hard structure would control variability better)
3. Reasonable costs			X			Large volume of sand means the project can benefit from economies of scale. Delivering a traditional solution could easily cost €100million and would not deliver the additional social and ecological benefits
4. Structural integrity					X	Using natural materials and processes means that there is no traditional “hard” structure which needs sufficient strength and stability. These softer methods/materials allow the “structure” to be added to in the future (i.e. after initial 10 year window).
5. Reliability				X		Due to the lack of mechanical parts, this solution is very reliable. However, as intervention (additional nourishment) will be needed during the 50 year design life it does not score the maximum.
6. Implementability					X	The dredging companies have a huge depth and breadth of experience in nourishment schemes, including the Sand Engine and major reclamation (polder) schemes both in the Netherlands and around the world. The implementability is very low risk hence scores highly
7. Adaptability					X	Considers the future by taking a 50 year design life and does not exclude future works if needed to cope with additional sea level rise/storminess than currently predicted.
8. Resilience					X	The bigger the beach cross-section, the better the beach/defence will be able to resist successive storms. It is also interesting that the largest waves come from the NW and so will partially counteract the longshore drift along the coast to the North. Post storm beach-building will occur once normal conditions resume.
9. Appropriate boundary conditions and loads				X		Consideration has been given to the longshore and crosshore transport as well as the design water level (1 in 10000 year level) and sea level rise. Further studies to model the likely distribution of the sediment in the longer term would be recommended.

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles	Check boxes Minimum - Maximum					Explanation
Continuity					X	This solution does not reduce the flow of water and sediment in this area and rather it relies on these flows to ensure a broad distribution of the beach nourishment.
No direct human disturbance				X		Compared to the traditional solution there is significantly less human disturbance of the dune ecosystem. However, the provision of a lovely big new beach will attract additional leisure users so there will still be some human disturbance of fledgling dune systems.
Indigenousness / Endogeneity			X			It is difficult to know what species will colonise the new habitats. Some early hints may be available from the Sand Engine report on the first 5 years (yet to be completed). Monitoring should be considered an integral part of this solution for Hondsbossche
Viability of populations			X			Again it is difficult to know how newly colonising populations will react; monitoring will be needed to determine their viability.
Opportunity for threathened species				X		By the development and extension of the dune system of the North Holland coast, there will be greater habitat available for threatened species, including those that will colonise pioneer zones.
Trophic web integrity			X			The effect on the web integrity will need to be determined through monitoring. Some preliminary hints might be available from the future sand engine reports.
Opportunity for ecological succession					X	As the sand moves onshore, pioneer species will have an opportunity to colonise. Due to the lack of human intervention in these processes, successive stages will also have the chance to develop.
Zone integrity					X	Using natural materials and processes does not constrain the land-water transition and allows for a more gradual transition than a traditional structure would.
Characteristic (in)organic cycles			X			There are still unknowns with regards to how the sediments from the North Sea will react when they are disturbed and exposed to the open air. Some preliminary recommendations could be disseminated from the monitoring at the Sand Engine. Further monitoring of the Hondsbossche area will also be necessary
Characteristic physical-chemical water quality			X			Additional beach forms can alter the direction and strength of currents; these will need to be monitored to ensure any changes are communicated to the relevant stakeholders (coastguards, kite surfers, swimmers etc.) and to inform future interventions.
Resilience					X	The new ecosystems will be more able to recover than in a traditional approach as they will have more time to establish and more space to adapt and recover from any ecosystem shocks.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

There are a number of aspects which would benefit from future monitoring. These will help to manage the inherent risks in a more innovative solution which does not try to control natural processes rather than working with them.

- **Ecological**
    - Specialised surveys to monitor species succession
    - Surveys to count fauna
    - Bathymetric/Lidar surveys to monitor movement of sand on and offshore
- **Engineering**
    - Regular surveys to assess the condition of the developing dune system and the performance against the design standard (to inform timing and scale of future interventions)
- **Social**
    - Monitoring of use by leisure users (including specialist user groups such as watersports, bird-watching)

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

CONTROL:
Control structures have been sacrificed (rock groynes); the main trade-off surrounding this element is that people are familiar with these kinds of coastal defences and therefore trust them. More innovative solutions present an inherent risk due to the large number of unknowns.

FINANCIAL:
There is likely to be a trade-off in terms of cost too as more material is likely to be needed than the traditional rock groyne and recharge solution. Additional cost may be incurred by the creation of the saline lagoons, especially if these are to be maintained long term (dunes could roll back onto this area in the longer term).
Due to large number of key stakeholders, the funding strategy is likely to be significantly more complex than a traditional approach. However, funding contributions could be received from environmental groups that are keen to promote or enhance certain species/habitats.

ECOLOGICAL:
There is also a trade-off on the ecological side – greater opportunity for habitats to develop is being provided (due to reduced disturbance) but there is still a large degree of uncertainty over what habitats will develop and which species will colonise.

Building with Nature Assignment

Case Title & Location:

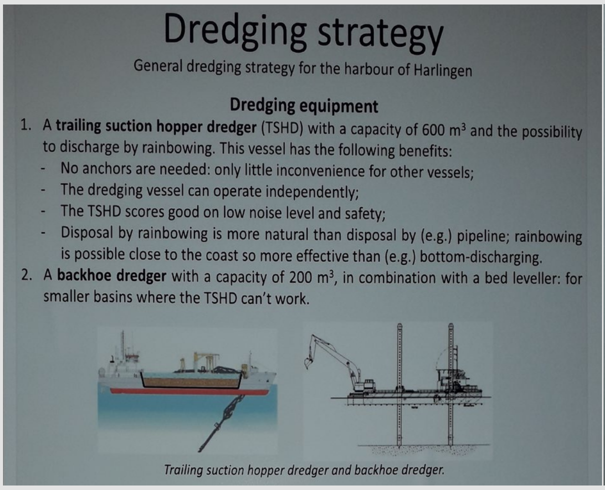
Nature-Friendly Sediment Disposal, Harlingen Harbour, Netherlands

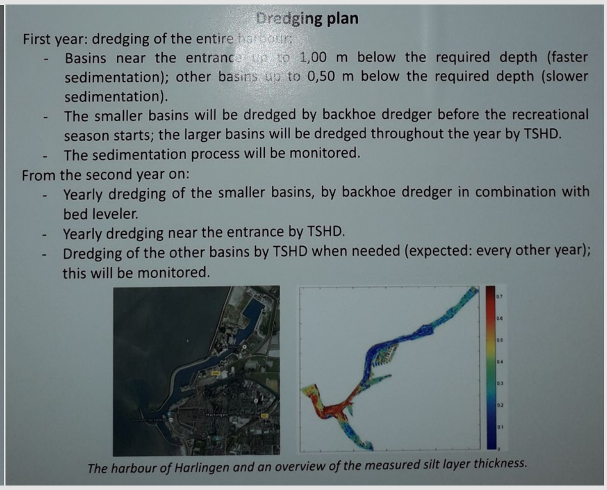
Your functional requirements (list at least 4):

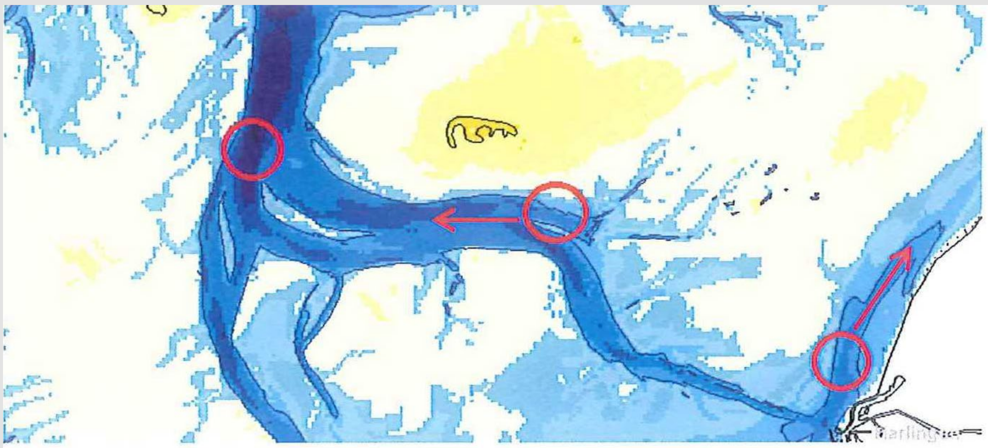
- Harlingen Harbour navigable, continuing to serve recreational, commercial and industrial shipping needs
- Disposal strategy that:
    - reduces the return flow of sediment to the harbour
    - utilizes natural processes
    - utilizes natural materials
    - promotes the development of salt marsh along the Wadden Sea coast

Design sketches:

Conventional solution (annotated)



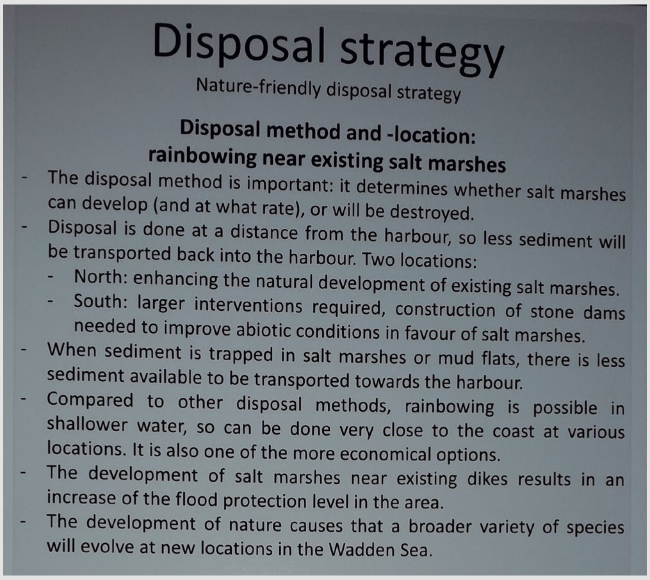




Disposal sites near Harlingen Harbour (bottom right).The conventional disposal strategy involves using the deeper westernmost sites, the middle one only on ebb as the predominant current is then directed westward. The easternmost site is very shallow.

BwN design (annotated sketch, indicating anticipated changes over time):

Nature-friendly disposal strategy to develop salt marshes at suitable locations along the Wadden Sea coast. Sediment is disposed at the easternmost site to induce the formation of salt marshes over time.

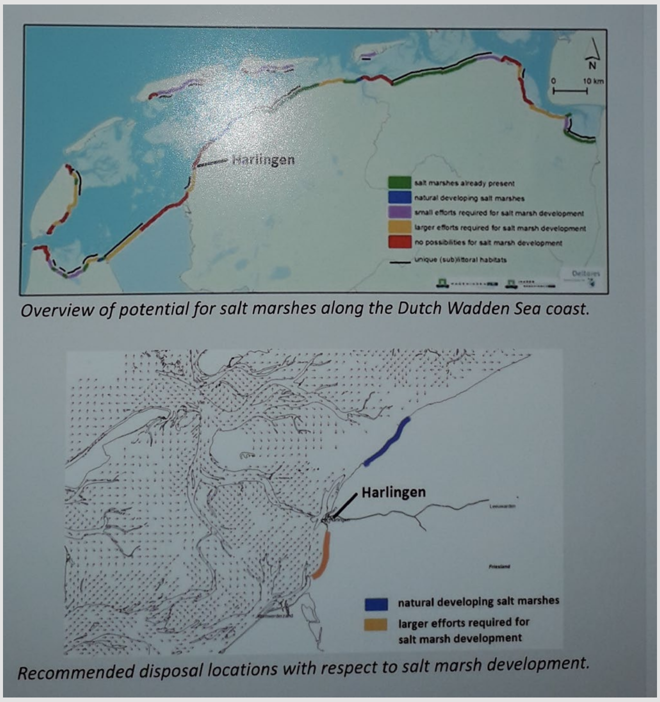


Disposal strategy

Nature-friendly disposal strategy

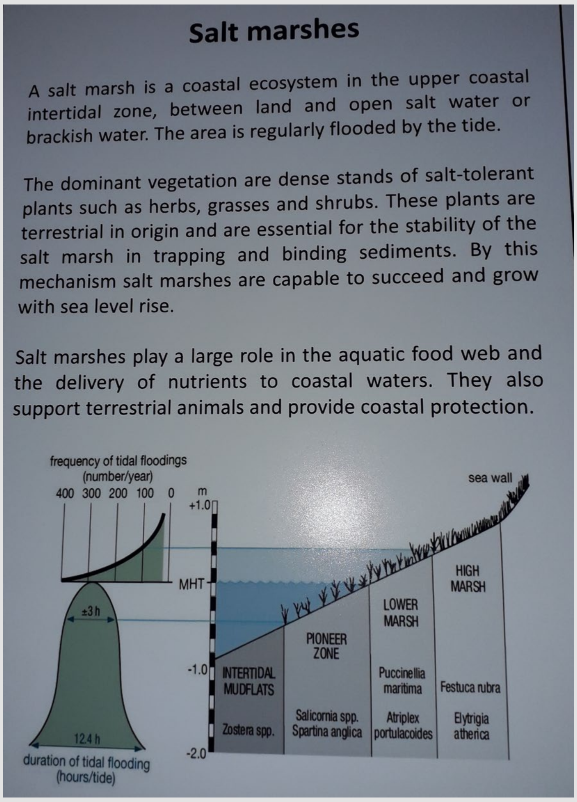
Disposal method and -location: rainbowing near existing salt marshes

- The disposal method is important: it determines whether salt marshes can develop (and at what rate), or will be destroyed.
- Disposal is done at a distance from the harbour, so less sediment will be transported back into the harbour. Two locations:
  - North: enhancing the natural development of existing salt marshes.
  - South: larger interventions required, construction of stone dams needed to improve abiotic conditions in favour of salt marshes.
- When sediment is trapped in salt marshes or mud flats, there is less sediment available to be transported towards the harbour.
- Compared to other disposal methods, rainbowing is possible in shallower water, so can be done very close to the coast at various locations. It is also one of the more economical options.
- The development of salt marshes near existing dikes results in an increase of the flood protection level in the area.
- The development of nature causes that a broader variety of species will evolve at new locations in the Wadden Sea.



Overview of potential for salt marshes along the Dutch Wadden Sea coast.

Recommended disposal locations with respect to salt marsh development.



Salt marshes

A salt marsh is a coastal ecosystem in the upper coastal intertidal zone, between land and open salt water or brackish water. The area is regularly flooded by the tide.

The dominant vegetation are dense stands of salt-tolerant plants such as herbs, grasses and shrubs. These plants are terrestrial in origin and are essential for the stability of the salt marsh in trapping and binding sediments. By this mechanism salt marshes are capable to succeed and grow with sea level rise.

Salt marshes play a large role in the aquatic food web and the delivery of nutrients to coastal waters. They also support terrestrial animals and provide coastal protection.

Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles	**Slider**					**Explanation**
	Minimum - Maximum					
1. Requisite standard					x	The navigational depth of the Harlingen harbour is maintained as required.
2. Control variability				x		The harbour depth is maintained by dredging and the disposal strategy of adding sediment in zones suitable for salt marsh development near to the coast induces less variability. In time, the return flow of sediment should reduce.
3. Reasonable costs		x				In the conventional strategy barges sail to the disposal site and discharge sediments by bottom dumping – a cheap and effective manner that requires sufficient depth. Now disposal is either by rainbowing or can only occur at certain stages of the tide when the water depth is sufficient. This makes the nature-friendly strategy more expensive.
4. Structural integrity					x	Dredging and nature-friendly disposal are sound solutions for which structural integrity is not required. Moreover, building salt marsh fixes the sediment in place over time.
5. Reliability					x	The strategy is reliable, dredging and disposal can go ahead as envisaged except for during heavy storms. Any effects of the storms can be addressed through slightly higher dredging and disposal volumes thereafter.
6. Implementability			x			Some issues of implementability could occur. The disposal area near the coast is shallow and can only be utilized at certain stages of the tide. The implementability would ave to be monitored in an ongoing fashion.
7. Adaptability					x	The dredging and disposal strategy is highly adaptable. The volumes can be adjusted as required, and alternative sites or access routes can be used should depth and associated implementability become a problem.
8. Resilience						Resilience to repeated events is inherent in this strategy. If additional sediment enters the harbour, the volumes dredged and disposed would go up somewhat. This is not anticipated to be a problem.
9. Appropriate boundary conditions and loads					x	Tidal flow data, wave and wind data as well as information on the sediments in the Wadden area were used in simulation models to determine the viability of the proposed nature-friendly strategy. Ten years of monitoring data were used in estimating potential salt marsh growth.

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles	**Slider**					**Explanation**
	Minimum - Maximum					
Continuity					x	The nature-friendly disposal strategy uses natural and continuous sediment transport and accretion processes.
No direct human disturbance		x				This is a weakness of the design. There is significant disturbance in the harbour by dredging and at the disposal site. However, the sediment arrives at the growing salt marsh by natural currents and processes.
Indigenousness / Endogeneity					x	Both mud flats – the precursors of growing salt marshes – and the salt marsh themselves are protected habitats, and are home to indigenous species. Threats by invasives are not increased in this design.
Viability of populations					x	Growing the area of mud flat and salt marsh will improve the viability of many resident species, and also of migratory birds for whom the Wadden Sea is an important nursery area, breeding ground and feed and rest area.
Opportunity for threathened species					x	The mud flats and salt marshes of the Wadden Sea form the most extensive wetland habitat of northwest Europe. Numerous threatened species inhabit these areas. Any increase in available habitat can be viewed as beneficial.
Trophic web integrity				x		Mudflats and salt marshes are associated with particular species and trophic webs. Because there are healthy salt marshes nearby and the sediment arrives via natural transport at the salt marsh, no threat to trophic web integrity is envsaged.
Opportunity for ecological succession					x	Ecological succession forms an intrinsic component of the design. The salt marsh will colonize accreting mud flats with pioneer species. As the pioneer zone becomes established it will transition to a later successionary stage, and so on.
Zone integrity					x	The zonation of salt marshes is one of their characteristic features. By supplying muddy sediments to them via natural transportation and accretion processes characteristic is strengthened.
Characteristic (in)organic cycles					x	The sediment disposed is of similar gran size and organic loading to the destination mud flat / salt marsh.
Characteristic physical-chemical water quality				x		Higher turbidity is present in the harbour when dredging occurs. However, the characteristic high turbidity and sediment load of the Wadden Sea is used in this design, which adds even more sediment to the water column at the disposal site. Howver, the additional load is confined to the near vicinity of the disposal site.
Resilience					x	Repeated storm events would have very little effect on the design and strategy. Any additional salt marsh increases the resilience of the Wadden Sea coast to storm surge. If damages occur, the designed nature friendly disposal just continues.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

Monitoring of the water depth at the nature-friendly disposal site would be required on an ongoing basis. Shoud depths become too shallow to effectively dispose there, alternative sites would need to be sought.

Monitoring of the salt marsh growth is required. The Fryske Gea presently undertakes annual monitoring of elevations, znation, and different plant species and birds. They could include the newly developing salt marsh in their monitoring programme.

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

The major difference between the conventional approach and this approach is the disposal strategy. In the conventional approach this is oriented to low cost and efficiency – dumping occurs via barge, in deeper waters, near the main channel. This means that the return flow of sediment is significant (possibly up to 40%). By choosing to build salt marsh with the sediment, we opt for a more expensive solution, but one that is more efficient in the long run and adds to the nature value and the coastal defence in the Wadden sea area.

Building with Nature Assignment

Case Title & Location:

Coastline Resilience for Demak, Indonesia

Your functional requirements (list at least 4):

Taking into account existing damage to the coastline, achieve sediment deposition at the coast by:

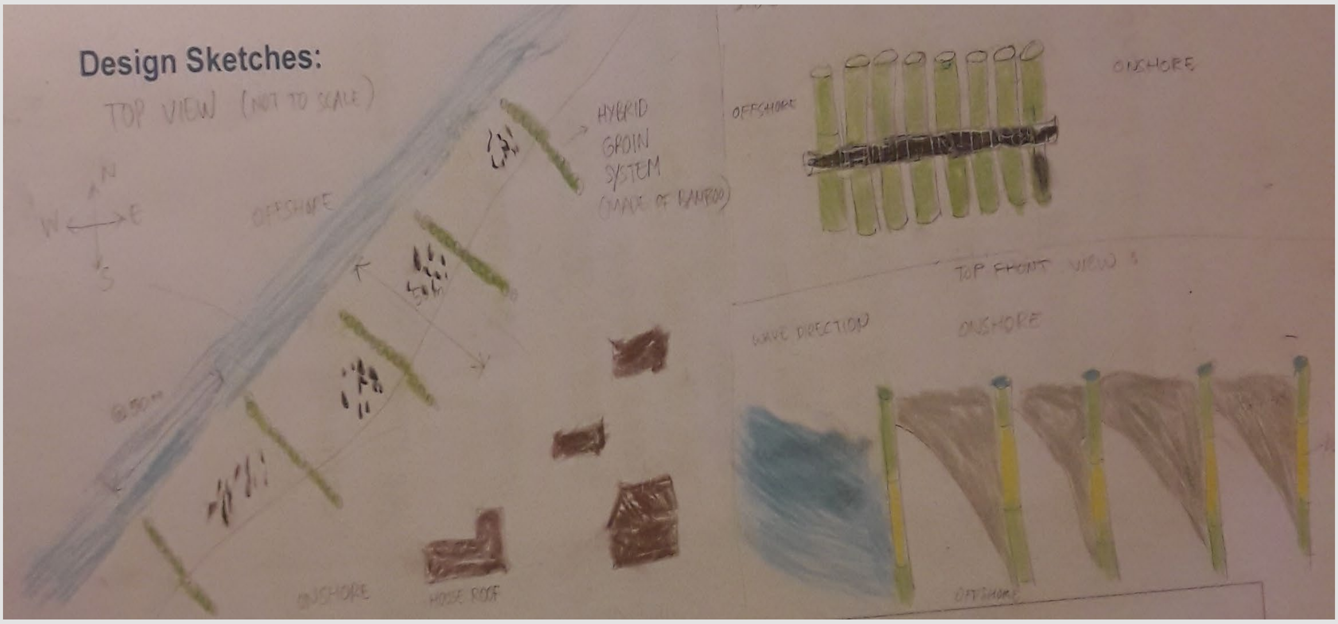
- Reducing the wave energy at the coast
- Catching sediment at the coast
- Keeping the captured sediment in place
- Preventing the loss of existing sediment.

Design sketches:

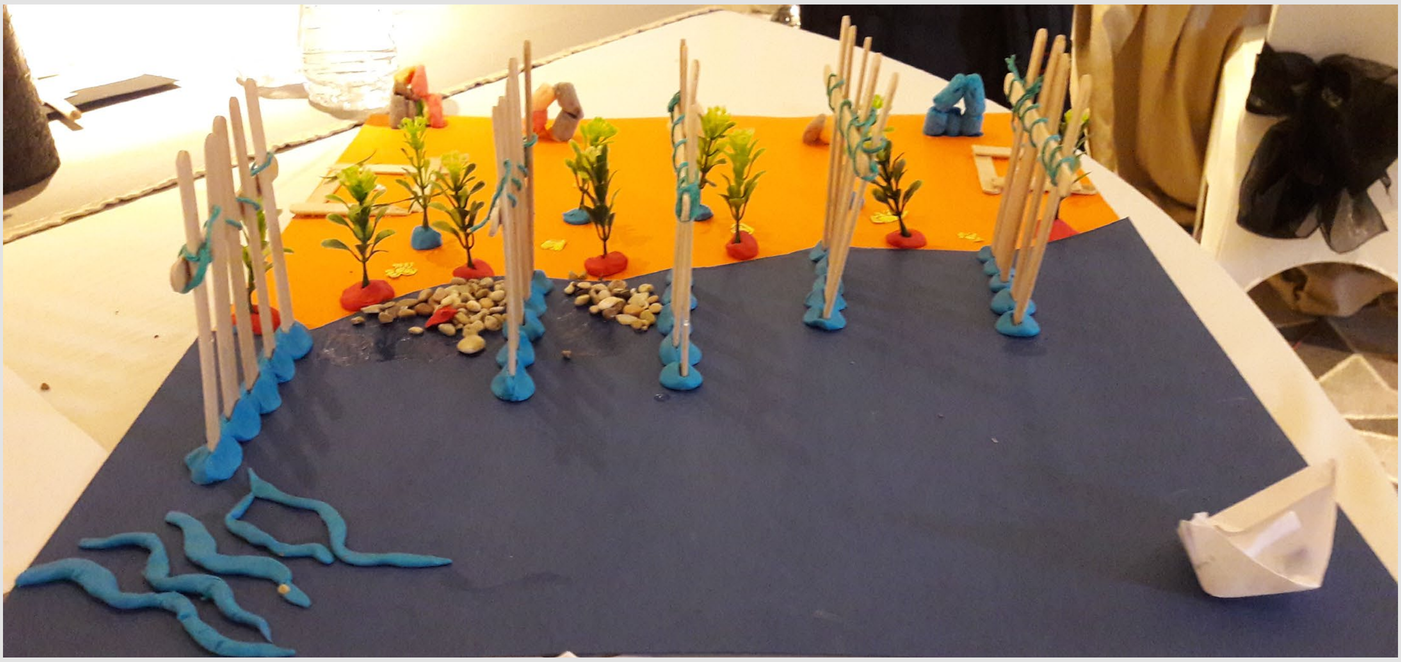
Conventional solution (annotated):

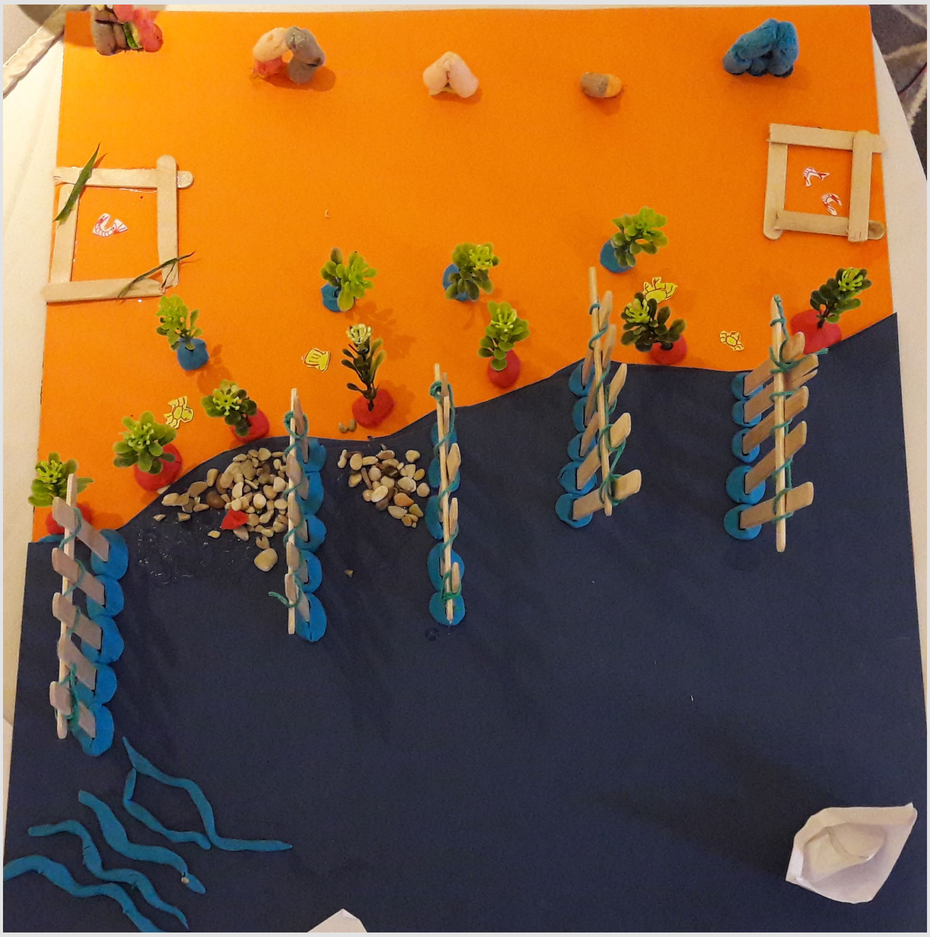
Solid breakwater to protect the coast from flooding, and to reduce erosion.
Requires costly measures to prevent scour and slumping of the structure.

BwN design (annotated sketch, indicating anticipated changes over time):

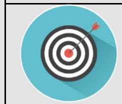
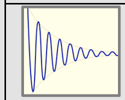
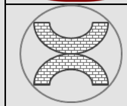
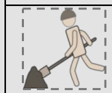
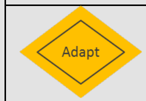
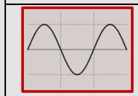


Design for cross-shore permeable groynes to be extended as sediment accretes nearer the coast. Photographs of the maquettes made to represent the design are included next.





Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles		Slider					Explanation
		Minimum - Maximum					
	1. Requisite standard		x				By choosing to use bamboo and a hybrid engineering approach, the requisite standard of erosio prevention is achieved, but minimally.
	2. Control variability			x			The structures are designed to dissipate avearge size waves and to cope with usual tidal ranges.
	3. Reasonable costs					x	The material used is readily available bamboo to minimize costs while maintaining standards.
	4. Structural integrity		x				The structures are relatively weak and can be damaged by wave action. A maintenance programme of treatment and rebuilding is required, as is monitoring of the structural integrity of the bamboo structure.
	5. Reliability			x			Need to treat and rebuild regularly to maintain the reliability.
	6. Implementability					x	Feasible, easy to build and to maintain with locally available resources and labour.
	7. Adaptability					x	New bamboo structures can easily be placed where they are found to be necessary, and existing structures can be raised if necessary. Very adaptable approach as the groynes are extended out as the shoreline accretes, certainly more so than a concrete hydrualic structure.
	8. Resilience		x				The bamboo structures are not necessarily resilient in an engineering sense – continuing to resist continued storms over time.
	9. Appropriate boundary conditions and loads					x	The boundary consitions for the entire Demak coast were considered and were used to determine requirements per stretch of coast depending on its state of damage. The nested and site specific consideration of the boundary consitions is a strength of the design.

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles	Slider					Explanation
	Minimum - Maximum					
Continuity					x	Permeable structure used to trap sediment, actually making use of the continuity principle in the design.
No direct human disturbance	x					Significant disturbance during construction, and possibly during maintenance and repair, but not as disturbing as the construction of concrete infrastructure.
Indigenousness / Endogeneity				x		Bamboo materials used to costruct the structure are natural to the area. The structures can be used by invasive crabs and clams.
Viability of populations				x		No isolated populations are known to occur in the area, and as no connective corridors are blocked on land or sea, population viability is not impacted and potentially enhanced by the envisaged growth of mangrove forests.
Opportunity for threathened species					x	Designed to offer opportunity to threated mangrove forests
Trophic web integrity			x			Invasive crabs and calms can be detrimental to trophic web integrity. This may be outweighed by the opportunities offered to indigenous species in mangrove forests.
Opportunity for ecological succession					x	New pioneer zones for mangrove colonization is provided. Ecological succession is stimulated.
Zone integrity					x	Zone itegrity is unaffected as tidal variation remains unimpeded. Eventually, a more extensive, ecologically valuable intertidal area is envisaged.
Characteristic (in)organic cycles				x		As erosion reduces and deposition begins, sediments rich in inorganic nutrients will be available for colonisation by mangroves along the coast.
Characteristic physical-chemical water quality				x		Similarly, no impedance is offered to water flow and characteristic sediment-laden waters will occur along the coast.
Resilience				x		Highly resilient solution. If a storm causes severe erosion, or damages the structures, they can easily be repaired and possibly more sediment placed where needed.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

Monitoring of the bamboo structure will occur once a month.
The sediment height is checked periodically. When the sediment height increases sufficiently, the permeable groyne will be extended further offshore. The condition of the sediment is also monitored to establish whether it can be used for planting mangrove seedlings.

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

The two major trade-offs applied here relate to the choice for permeable groynes, and the choice to use bamboo to make the structures. Permeable groynes facilitate continuity of water and sediment movement and work with the forces of nature to produce sheltered areas where sediment can accumulate. The choice for bamboo relates to the availability of the material and that it is natural to the area. Both of these trade-offs deviate from standard hydraulic engineering solutions which could require the design and construction of concrete flood defences.

The choice is for hybrid engineering that takes into account the existing damage to the coastline and seeks to use natural materials and natural processes in Building with Nature for people.

Acknowledgements:
The universty lecturers of Indonesia who participated in Building with Nature Indonesia training are acknowledged for their beautiful designs.

Building with Nature Assignment

Case Title & Location:

Green Mussels Breakwater System, Demak, Indonesia

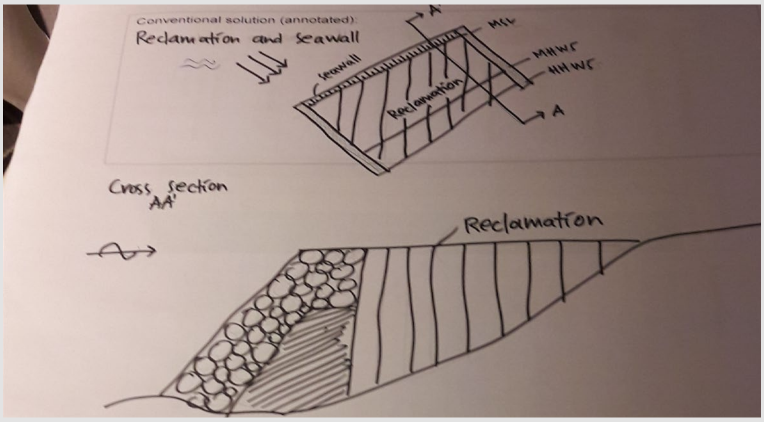
Your functional requirements (list at least 4):

- Accretion of coastal fine sediments
- Shoreline management
- Restoring local ecosystem
- Restoring local livelihoods.

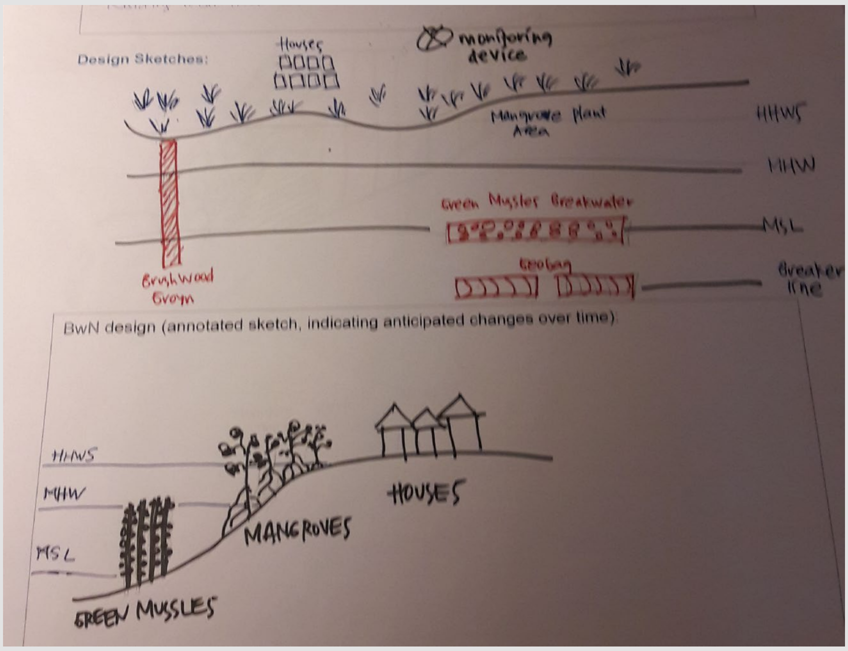
Design sketches:

Conventional solution (annotated):

Seawall to protect the coast from erosion, allowing reclamation behind it. Requires costly measures to prevent scour and slumping of the seawall.



BwN design (annotated sketch, indicating anticipated changes over time):



Design for a bamboo and green mussel breakwater located around mean sea level (MSL) with a geobag breakwater offshore of this and a mangrove planting area inshore of the shelter provided by the geobags and green mussels.

The maquettes made to represent this design are


BRUSHWOOD GROYN
GREEN MUSSLE BREAKWATER
GEOBAG
BABY MANGROVE
GROWN MANGROVE
CURRENT SHORELINE


BABY MANGROVE
GROWN MANGROVE
CURRENT SHORELINE
ORIGINAL SHORELINE
GREEN MUSSLE BREAKWATER
BRUSHWOOD GROYN
GEOBAG

Consider the following principles, then rate (with an X in 1 of the 5 boxes) the extent to which you have taken this principle into account in your new design (remember, this is an exercise in trade-offs, so you will not be able to meet every principle fully). Then explain why you have rated your design accordingly.

Engineering principles		Slider					Explanation
		Minimum - Maximum					
	1. Requisite standard		x				Bamboos with green mussels, geobags and brushwood groynes are built to withstand a flood with 1-year return period. Maintenance and annual rebuilding are necessary to ensure the structures continue to meet standards.
	2. Control variability				x		The effects of coastal surges and high waves associated with storms with a 1-year return period are reduced, serving to create a more sheltered and less variable environment between the structures and the shoreline. The combination of structures increases the ability to retain sediment inshore above that of a single structure.
	3. Reasonable costs				x		Total cost is relatively low because the materials, such as bamboo, sand for the geobags, and brushwood can be sourced locally.
	4. Structural integrity				x		Strong wave action could affect the integrity of the individual structures. Monitoring after storms is required to ensure that each component remains sound or is repaired if required.
	5. Reliability				x		The combination of structures – geobags, bamboo with geomussels and brushwood, enhances the reliability of the overall design. The structure is more reliable than its strongest element – the geobags.
	6. Implementability					x	Feasible, easy to build and to maintain with locally available resources and labour, provided that appropriate training is given.
	7. Adaptability					x	As the functionality of the geobags and green mussels reduces with time, the mangroves become established and supply the necessary coastal protection.
	8. Resilience					x	The combination of structures in one overall coastal defence infrastructure design, increases its resilience. It is likely to be able to withstand a second storm even if there is some damage from a first storm, and can easily be repaired or rebuilt if necessary.
	9. Appropriate boundary conditions and loads				x		The boundary consitions for the entire Demak coast were used to determine requirements for this part of the coast. Site specific conditions and loads were then used to design the solutions.

As before, consider the following ecological principles and rate the extent to which you have taken this principle into account in your new design, then provide an explanation.

Ecological principles	**Slider**					**Explanation**
	Minimum - Maximum					
Continuity					**x**	Structures allow water and sediment to flow – the geobags ado not form a solid breakwater, but are placed in two segments. The other structures are permeable.
No direct human disturbance		**x**				Significant disturbance during construction. Structures also require maintenance by humans.
Indigenousness / Endogeneity					**x**	The bamboo structures are designed to stimulate the growth of indigenous green mussels.
Viability of populations					**x**	The viability of the green mussel population is improved. Growth of mangrove forest is stimulated.
Opportunity for threathened species					**x**	Designed to offer opportunity to threated mangrove forests.
Trophic web integrity				**x**		The growth of mangroves offers opportunities offered to other species cohabiting in the forests.
Opportunity for ecological succession					**x**	New pioneer zones for mangrove colonization are provided. When the sediment is at the right height the seeds of *Avicenea marina* will colonize the area.
Zone integrity				**x**		A lower energy intertidal zone is created where mangroves can grow. This will eventally improve zone integrity, which is unlikely to be affected at the beginning.
Characteristic (in)organic cycles				**x**		Re-establishing mussels and mangroves will re-introduce and strengthen characteristic organic cycles, in particular.
Characteristic physical-chemical water quality				**x**		Mussels actively filter the water, and mangroves also improve water quality.
Resilience					**x**	Highly resilient solution. If a storm causes damage, the combination of structures can probably still withstand another storm. They can also be repaired fairly easily.

Monitoring and Risk assessment

In a short paragraph, discuss any future monitoring and risk assessment required for your Building with Nature design.

Monitor shoreline change and mangrove growth using cameras, sensors etc. Public authority to check periodically that planned maintenance by local community occurs.

The design uses a combination of structures to reduce the risk of structural failure. Monitoring and maintenance also reduce this risk.

Trade-offs

Comment on any trade-offs you made in order to introduce more ecological principles. In other words, describe how your Building with Nature sketch differs from the conventional approach (max 200 words).

Both the conventional and the proposed Building with Nature solution address the coastal erosion problem. This solution has more benefits for mangrove ecosystems and has more potential generate income for the local community from the green mussels, and can strengthen the capacity of local people to co-manage their coast.

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