



Welcome to the first issue of footprints - a newsletter dedicated to beach drainage /beach-face dewatering (BD) technology - 'a soft solution to soft shoreline erosion'.

There are a number of reasons for producing this newsletter,

- **Cooperation:** a lot of BD research & project development work has been going on around the world in recent years but a forum for discussion & cooperation between the many BD researchers, practitioners & supporters has not developed.
- **The Jury is in:** the last time the technology received any real scrutiny from its peers in the scientific & engineering community, BD benefits were presented as inconclusive. This review was based on the then available 1995 data - since then another 16 BD systems have been installed and scientific research & understanding has advanced.
- **Profile:** BD hardly registers on the 'map' when coastal practitioners are commissioned to investigate the options for protecting a soft coastline from erosion.
- **Change:** the technical and commercial development of BD has been lead since 1981 by Hans Vesterby at the Danish Geotechnical Institute (now known as GEO). Hans has now retired from GEO and the world-wide patent protection enjoyed by GEO is expiring. A new cooperative business model needs to emerge.
- **Environment:** sea levels are rising - weather patterns may be changing. Coastal erosion is getting more attention. So should alternative 'soft' management techniques.
- **Self-interest:** I am personally involved in BD project development.

My apologies if you feel you've been spammed! The circulation list for this first issue includes 'all & sundry' from my address book (& email addresses provided to me by fellow BD enthusiasts). Please send me an email if you want to 'escape' the circulation list... TLRichards@bigfoot.com. I hope we will soon have a permanent web-based home from where you can elect to receive footprints and also find other information on BD. Dr Heidi Shaw has kindly provided an immediate collection point for the newsletter and other information at www.beachdrainage.com

If you are new to BD technology: check out the back page which provides an introduction and a historical perspective.

For this first issue of footprints I've included a section dedicated to research & academic study (page 2). Page 4 focuses on project activities around the world and Page 6 is a feature from Hans Vesterby providing his personal perspective on the BD projects that he has been involved with over the past 22 years.

The rest of this editorial is directed to those with an interest in the continued development of BD technology (& this newsletter). I thank you all for your contributions to this 1st footprint and I look forward to your continued support. I would like to open a discussion on the future structure of this newsletter and a framework for cooperation between those currently involved in BD.

Future content for footprints could include,

- Notice on the publication of research activities and conference participation
- Work & research opportunities around the world
- Discussion on a future workshop /website /'member' forum
- World-wide project development activities
- New project installations /Operational reports
- Discussion on study criteria, site acceptance & environmental aspects
- Reviews on equipment & installation methods
- Advertising (consultants, contractors, vendors).

I would welcome your additions, comments and advise on any of the above. **I believe it is imperative that we establish a member forum to discuss and plan the BD community's future direction.** Offers of help /support would also be appreciated.

Academic & Research Activity

To kick this section off, I've got feed-back from various people, universities & organisations that are currently or have recently been involved in BD research or study. There has been a history of collaboration between some of the universities but, as yet, no global forum has evolved to help coordinate research activities around the world. I hope that footprints can initiate this process.

Universitat de Barcelona, Spain

Barcelona University became involved in BD in 1994 through collaboration with the BMS licensee in Spain. They have been engaged as a technical consultant for project activity (studies & design) and academic research associated with the commercial installations. Two 300m systems have been installed in the Ebro Delta, South of Barcelona. Riumar 1 was installed in 1996 and Riumar 2 was installed in 1999. Maintenance problems including storm damage to the discharge pipelines have prevented the systems from operating to their full potential for periods since their installation but it is anticipated that these operational issues will be resolved in the near future. These operational problems have not prevented positive effects from BD being evident. The coastline has stabilized and backshore dune ridge consolidation /growth are apparent from sand supplied from the BD frontal beach.

Dr Carlota Montori completed her PhD in 2002, based on field and experimental research activity associated with this BD work. Barcelona University has collaborated with universities in France and Italy on various European projects associated with BD.

The publication of new research material in eminent and plans are being made for presenting at future international coastal conferences. Work is under way on developing new projects in Spain, the Balearic Islands and in Portugal.

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Southampton University, UK

www.beachdrainage.com

The Department of Civil and Environmental Engineering at the University of Southampton has been carrying out research into beach drainage since 1998. The research has included full scale monitoring and performance assessment, and physical modeling using lightweight sediment.

Our research has been funded by the Engineering and Physical Sciences Research Council (EPSRC), and presentation at the Coasts and Ports 2003 has been funded by the Royal Society. We are working in collaboration with the Borough of Poole, and the Southampton Oceanography Centre.

Findings will be presented at the Coasts and Ports Australasian Conference 2003.

Contact: Dr. Heidi Shaw hsm2@soton.ac.uk

Polytechnic de Bari, Italy

Prof. Leonardo Damiani and his associates have been busy with preparations for presenting at the **6th International Conference on Coastal Engineering 23-25 June 2003, Cadiz**. www.wessex.ac.uk. Three papers on BD were originally planned for the conference,

- The design of a physical model reproducing the beach drainage system **L Damiani & G Ranieri**
- A numerical simulation of the beach drainage system **G Chiaia & G Ranieri**
- Coastal protection with BMS: the first experience in Italy **L Damiani, G Ranieri & R Rossetti**

However I understand that due to Roberto Rossetti's ongoing BD installation commitments not all of these papers will be presented (see Roberto's report in the following 'Projects' section, page 4). I hope to have a full report on these papers and the conference in the next issue.

Contact: Prof. Leonardo Damiani l.damiani@poliba.it

Contributions from a number of other universities and researchers are planned for future issues.

Carl Linderoth, the promoter and developer for BD in France and Belgium, is working closely with three French universities for the monitoring and reporting on operational systems. His report is available in the following 'projects' section (page 4).

Reference Material

BD technology has, in many parts of the world, failed to gain acceptance within the coastal expert community. Some of the criticism focuses on the dearth of published material that is readily found on the subject. Any independent critique of the technology will invariably (and often, only) pull up the following... *TURNER, I.L. AND LEATHERMAN, S.P. (1997): Beach dewatering as a "soft" engineering solution to coastal erosion – A history and critical review. Journal of coastal research, Vol. 13, No. 4, pages 1050-1063.*

This report concluded that ... *"the early promise of the beach dewatering concept is yet to be adequately demonstrated at the prototype scale. The installation of new systems is to be encouraged as long as it is fully recognized by all parties that the results of previous installations remain inconclusive. New dewatering sites should at present be regarded as experimental, rather than a proven solution to erosion management."*

Although this report was published in 1997, its references were from 1995 or earlier. Since this report, 14 BD systems have been put into operation and a great deal of theoretical and project related research has been undertaken.

It is up to the BD community to get enough new data published and accessible to challenge the authors' conclusions. This said, there is a surprising number of academic papers published, related to the subject, when you start hunting. Dr. Shaw has kindly made some of this information available on her website as PDF files (www.beachdrainage.com).

Extensive reference lists are provided with these reports. We will grow the download list with time & permission. If you are aware of, or have available, other published data on the subject (any language) please let us know. A lot of material is in the process of being published. Three papers were prepared for the Cadiz conference but only one or two, I believe, will make their appointed appearance at this time. Drs. Shaw and Montori will be publishing material based on their respective PhD's in the near future.

The UK based CIRIA is preparing a new version of Beach Management for Coastal Engineers where it has been proposed to include a section on BD. This may provide a good opportunity to establish a greater recognition of BD.

Karsten Mangor has included a section on BD technology in his book ... **Shoreline Management Guidelines** (ISBN 87-981950-9-3 (April 2001) published by the Danish Hydraulics Institute (DHI), in which he concludes that:

"The beach drain is best suited for the management of beaches with the following characteristics:

- *Sandy beaches*
- *Moderately exposed to waves*
- *Exposed to tide*
- *Suffering from high groundwater table on the coast and on the beach*
- *Exposed to seasonal fluctuations of the shoreline*
- *Exposed to minor long-term beach erosion*
- *Locations with a narrow beach, where a wider beach is desired*

The beach drain is, however, not recommended as primary shore or coastal protection at locations with the following characteristics:

- *Severely exposed locations*
- *Protected locations*
- *Locations exposed to severe long-term shore erosion and coast erosion".*

Karsten is the Chief Engineer, Coastal Engineering & Environment for the DHI. He became involved with BD in 1997. DHI undertook a software development program in 1999 based on MIKE SHE & MIKE 11 software that produced a BD modelling tool and design aid for Hans Vesterby at the DGI. Some details on this model are given below.

Beach Drainage – Hydrodynamic Model

The following are extracts from Hans Vesterby's paper 'Modelling Groundwater Flow in Beach Profiles for Optimising Stabilising Measures' presentation at the International Coastal Symposium 2000, Rotorua, New Zealand, 24 to 28 April 2000...

"The sediment transport mechanisms in the wave run-up zone are very complex and until today no mathematical model exists that can describe these processes in sufficient detail. The sediment transport mechanisms across an unsaturated beach face are not to be quantified yet, but the effect of a present unsaturated area can be proportionally evaluated by determining the flow patterns, the exit point and the amount of water discharged for manipulation.

The groundwater hydrodynamics can be simulated in the mathematical model which has been developed for the Danish Geotechnical Institute by the Danish Hydraulic Institute (now DHI Water & Environment – Ed.) by merging the hydrological model MIKE SHE covering the groundwater dynamics, and MIKE 11 simulating the influence of sea level fluctuations and wave run-ups."

"It simulates in detail the groundwater flow with respect to the flux from the hinterland, in and out flow through the beach face caused by wave and tidal variations relevant for the beach profile and predominating hydrological characteristics. By manipulation of the groundwater table the model output describes the variation in potential head for each calculation layer, the drain flow, the groundwater flow pattern as well as the fluxes and water content in the unsaturated zone."

Details on other modelling work are available at www.beachdrainage.com.

Commercial Projects & Business Development

Newsletter contributions have been received from BD developers, promoters & clients in the following countries:

France

Carl Linderoth, Directeur for Ecoplage s.a.r.l., has provided the following commentary on BD activity in France...

"Our policy is to install three experimental systems, one on each maritime façade (Channel/North Sea, Atlantic Ocean and Mediterranean Sea), and have them tested by the Ministry of Equipment (responsible for coastal protection) in close cooperation with local universities. They will monitor the results of each system for a period of 3 years before giving their official conclusions.

1st installation: Les Sables d'Olonne (Atlantic ocean, tidal range approx. 6 m.)

- 1st phase: 300 m single drain system in April 1999
- Positive results after test period of 3 years
- 2nd phase; extension to a 600 m double drain system in April 2002
- Scientific monitoring by Prof. A. Miossec and P. Fattal from the University of Nantes.

2nd installation: Villers sur Mer (Channel, tidal range approx. 7 m)

- 1st phase: 300 m double drain system in April 2003
- Scientific monitoring by Prof. F. Levoy from the University of Caen.

3rd installation: Saint Raphaël (Mediterranean sea, tidal range approx. 0,4 m)

- 600 m single drain system presently under installation until the end of the year 2003
- Scientific monitoring by Prof. M. Provensal from the University of Aix/Marseille.

The interest is strong from state authorities and coastal communities to experiment with this new innovative ecological solution against sea erosion, as is proven by the fact that after the system was successfully tested during 3 years in Les Sables d'Olonne, we were allowed to build the 2nd phase and 2 new systems."

Contact: Carl Fredrik Linderoth, Ecoplage cflin@attglobal.net

Italy

<http://www.bmsonline.it/>

Roberto Rossetti advises that they are too busy installing new systems to provide a full report on BD activity in Italy for this issue of footprints! Two new projects are under construction at Alassio and Ravenna. Due to this work load they have also had to pull out of the Cadiz Coastal Engineering Conference where a paper on their BD activities in Italy was to be presented (three BD papers were originally proposed – ref. Prof. Damiani's comments in the previous section)

You can see details on their three Lido di Ostia BD systems, installed in 2000, on their website (link above).

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UK

Restormel Borough Council in Cornwall installed a BD system at Towan Beach, Newquay in 1994. This was an experimental system at the time and was installed in a less than ideal environment for the best function of a BD system (embayed beach /closed system, seawall wave reflection and 7m tides). The system was intended to displace the need for major seawall remediation by increasing the level of sand in front of the seawall (preventing undermining) but has not been entirely successful in achieving that objective. Serious denudation still occurs during long spells of NE winds but recovery seems to occur more quickly. A spin-off benefit is a dry beach for the many visitors to this popular spot. Operating costs average about £4-5000 per year.

Steve Burstow, RBC Engineer has been intimately involved in the project since inception. He advises that long term monitoring data on the system has yet to be studied in depth but he is now considering the possibility of a new BD installation on another beach in Newquay.

Contact: Steve Burstow, RBC sburstow@restormel.gov.uk

Germany

The first system was installed in Markgrafenheide in 2000. Modifications to the pumping system have delayed the release of study work associated with the system by Universitat Rostock. Results from the studies will soon be released and Torsten advises that they are optimistic about the future for BD technology in Germany.

Contact: Torsten Knoblauch, Clement Yacht Harbour Systems GmbH info@clement-systems.de

Malaysia

Malaysia also suffers from the 'new' technology syndrome and as usual, the technical community is the slowest to adopt and/or change. The three BD projects thus far in this country have been driven by the politicians and administrators who were ripe and ready for a change from the ugly hard structures. It is ironic that the technical folks are now being challenged to make BD work in Malaysia.

Apex Beach Management Sdn Bhd (ABMSB) signed on the BD technology with then DGI in 1997. The first BD project was commissioned in October 1998 by the National Erosion Control Council of Malaysia and managed by the Drainage and Irrigation Department (DID). This was for 1000 m at the Pantai Cahaya Bulan beach in Kota Bahu. However, because of DID's technical

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nature and difficulty in accepting the 'new' technology the project was stretched over 1-1/2 years before being given final approval to commence physical work. Additional difficulty ensued when the appointed construction contractor refused to heed advice on recommended methods of construction. Until today (over two years after start of construction) the system is still yet to be tested and commissioned to DID's satisfaction.

Two additional sites awarded for BD implementation by the Parliament of Malaysia were for the Port Dickson and Morib beaches. This time it is managed by the Public Works Department (PWD) of Malaysia. Feasibility studies by Hans Vesterby were completed early 2003 and construction drawings are currently underway.

Contact: Dr Rozlan Taha, ABMSB mtrozl@pc.jaring.my

New Zealand

Beach Systems Ltd has been promoting BD technology in NZ since 2000. Progress has been slow. When a community is debating an investment in coastal protection, it is usually about defending assets behind the beach and who has to pay for this. Eroding beaches that threaten properties (& that are potentially ideal for BD protection) are also 'mined' with history, politics and factions. Often, the beach has been sacrificed. Getting the 'win-win' BD option into the debate is an ongoing battle. Many of the local and international coastal experts who guide potential client councils and the community are not willing to consider a BD technology option based on its current low profile. Its winter in NZ – I'm hoping for a thaw in attitudes as summer approaches.

The most advanced project to date has been with the Gisborne District Council. A feasibility study was carried out on Wainui Beach in Feb03 with the assistance of Opus International Consultants. A Gisborne Herald report on the study can be viewed at www.gisborneherald.co.nz/archives/February2k3/news/news_25-02-2k3.htm (3rd article). GDC have been great supporters of BD over the last 3 years but have decided not to proceed with a BD solution at this stage. Hans Vesterby came out from Denmark to guide this first study. We were also hosted by the Kapiti Coast District Council at this time, conducting site inspections on four erosion prone beaches. A proposal has been given to undertake the next stage of feasibility study.

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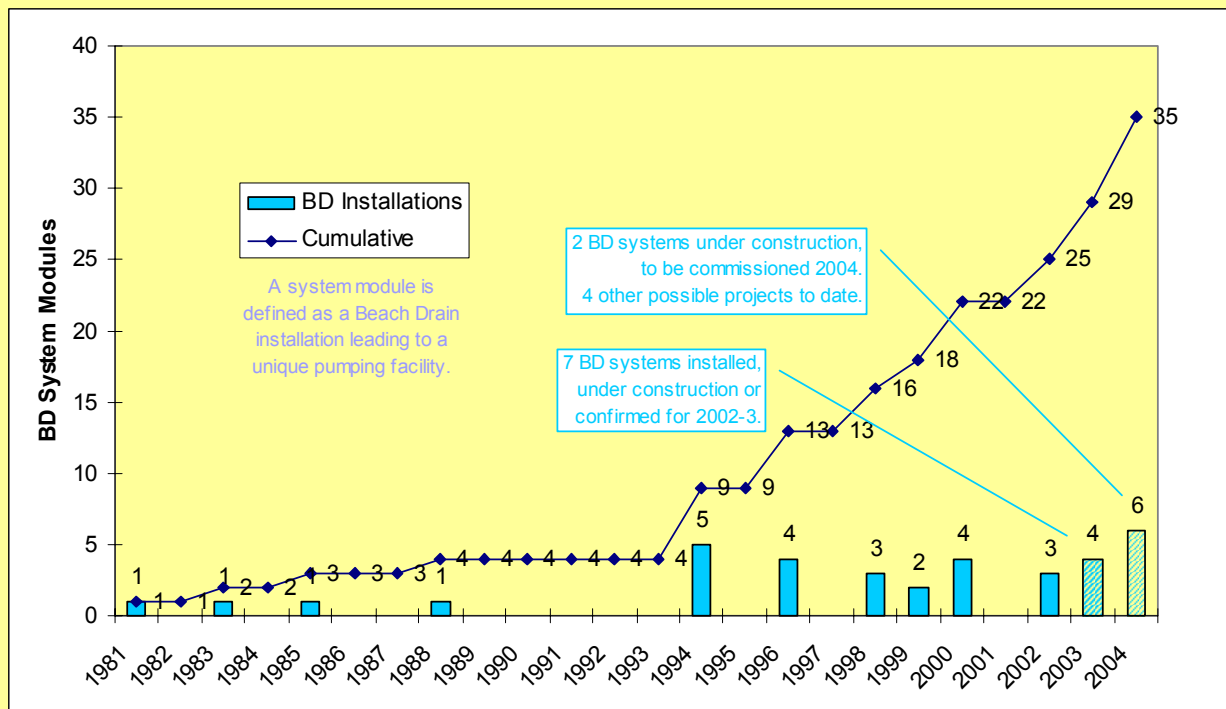
Oman

A collaborative venture with the Ministry of Regional Municipalities Environment and Water Resources to implement ShoreGro technology is now being reviewed as the most promising option for the coastal environment in Oman. This has gained technical recognition in comparison to concrete sea walls and nourishment with beneficial budget savings. There is a willingness to accept the 'new technology' as an environmental advance over conventional beach structures.

A new hotel complex is under construction where the developers are keen to preserve the natural beauty of an enclosed bay and where safe bathing waters are a priority. These fit well with the ShoreGro objectives of BD technology.

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The table below shows the progression of BD system installations around the world since 1981 & planning for 2003/4.



Two of the systems were installed as trial or experimental facilities (1985 & 1998) and have subsequently ceased operation. A third became redundant following a neighbouring nourishment program.

Hans on footprints

Hans Vesterby has been the driving force behind the BD technology from its accidental birth on a beach in Denmark. He has designed and directed the installation of most of the BD installations around the world including the original in 1981. Hans has now retired but maintains his interest in advancing BD technology through his continued support of BD practitioners around the world.



Hans has agreed to contribute to *footprints* with a regular feature. He begins with a historical perspective on installations starting with the original in 1981.

The story of Hirtshals West

- a shocker with a happy ending

The request for clean sea water

The North Sea Research Center was constructed at Hirtshals on the west coast of Denmark in 1981. The centre included an aquarium for salt water fish with wave and test tanks for fishing equipment testing. These facilities required large volumes of filtered sea water as did the Center's 'heat pump' heating system (total: 400m³/hour). Attempts had been made to utilise seawater through off-shore intakes but the water was too contaminated for the fish aquarium due to the waste water discharged from the heavy fish industry in and around Hirtshals.

At the time, I was the MD for the well drilling company (subsidiary to the Danish Geotechnical Institute) that, among other activities, was establishing water wells for the Hirtshals Municipality and most of the fish industry in the area. I was challenged with finding a suitable solution for fulfilling the requirement for clean sea water in the necessary quantity.

Investigation and design

With the idea that the local beach could substitute for the sand filters found in waterworks producing potable water, a test well was established in a sandy beach just west of the harbour of Hirtshals. The results of the pumping tests and the chemical and organic water analyses looked promising. However, in order to reclaim the necessary quantity of salt water the small, triangular beach (length approximately 250m and average width 20m) should be holed with wells like a 'Swiss cheese'.

Because it would be difficult to establish, protect and maintain a properly working collection system from a huge number of vertical wells, I proposed to substitute the wells by one 'horizontal' well (drain) sloping towards a pumping station from where the collected sea water could be pumped to the North Sea Center situated several kilometres away through a buried pipeline.

Based on the results from the hydraulic tests made on the test well and grain size analyses from sand samples collected from investigation bore holes in the alignment for the drain, the following sea water intake design was finalised: a 'horizontal' well, 220 metres long and dimensioned similar to a water well with slotted well pipe surrounded by filter gravel complying with the filter criteria for the natural beach deposits. The wave run up on the fore-shore was covered by a lot of foam from the contaminated sea water so it was deemed necessary (for optimal cleaning) to prevent the water from percolating directly down to the drain. To help augment this, an impermeable membrane was incorporated in the excavation backfill half a metre below the beach face.

Success and nightmare

The salt water drain was installed in August-September 1981, tested in mid September and activated by the end of September 1981. The system produced crystal clean sea water in a quantity of 460m³/hour and a quality that could cope with the standard requirements for drinking water (except from the salinity) – everybody was happy at that time.



Pre-installation, 1981

During the following winter period the drain pumps were running more or less continuously for supplying the heat-pump system. A reduction of the drain flow was registered and by March 1982 the drain flow had reduced to approximately 60% of the initial value. I felt my design ability questioned and on top of this the citizens of Hirtshals were complaining about sand in the streets transported by the wind from the location of the 'horizontal' well.

Trouble shooting and remedial measures

Investigation of the site (with installation of piezometres in cross sections along the drain alignment) indicated that the drain itself functioned as intended and, that a significant accretion of sand had taken place over and seawards of the drain. It was also shown that the coastline had moved 20 to 30 metres further seaward in front of the drain. It was concluded that the filter around the drain was not clogged and that the increased flow path from the sea to the drain location was the reason for the registered decrease in water intake. It was verified that the sand in the streets of Hirtshals had originated from strong winds that picked up the dry sand on top of the drain. Snow fences were installed to control the blowing sand and sand dunes built higher and higher. 'Excess' sand was trucked away to nourish a nearby beach.



As long as people in Hirtshals could remember the original beach had maintained its height and narrow width. The beach is located upstream of the protection given by Hirtshals harbour so a sudden migration of sand could not have caused the shoreline to move seawards. Moving the drain structure seawards was suggested but I proposed testing to verify that this would achieve the desired result. In June 1982 a 15 metre long fascine was installed close to the new shoreline. It was connected to the middle of the original drain structure in 1 July 1982. Within a few weeks the beach growth was repeated. Sand accreted over and seaward of the fascine and the shoreline moved further out forming a peninsula in front of the fascine.

By then it had become obvious that the pumping of water from the beach deposits was the primary process behind the registered changes and that a relocation of the drain structure would not solve the problem. Consequently, it was decided to lengthen the existing drain by 220 metres in a new area established upstream to the old beach. This section was activated by the end of November 1982.

Monitoring surveys during the five month winter period of 1982-83 showed pronounced and significant accretion of sand over and seaward of the total drain length and that the shoreline had apparently stabilized some 25 metres in front of the drain position. The drain system now provided for a sufficient amount of clean sea water to the North Sea Center.

Commercialized reproduction

The use of the clean salt water in the heat-pump system for the North Sea Center require full-time pumping from the drain during the winter period resulting in the observed accretion and reduction of drain flow. In order to keep a sufficient flow rate the 'excess' sand is harvested and sold for nourishing a nearby beach. It has become a standard procedure each autumn to invite tenders for the removal of some 25,000m³ of sand from the Hirtshals West site. At the time for the call for tenders the beach is as narrow as initially in 1981 but it is known through long experience that the beach will accrete as soon as the drain pumps are running regularly in winter.

The seed for the future

It was initially concluded that the reason for the observed sand accretion was the flow of water into the beach which increased the effective drag forces on the sediment particles and reduced the amount of backwash of the wave run-up. By simple explanation if all water from the wave run-up should soak down to the drain, then all sand brought up by the surging waves would be deposited on the beach face. A minor reduction of the backwash had tipped the dynamic equilibrium towards accretion. We are now aware of the scientific principles behind the effect on the stability of the foreshore by manipulating the ground water table in the beach deposits and that this had long been known and published by coastal experts.

Subsequent studies of the available literature on the subject revealed that the first conclusion was neither totally wrong nor definitively correct but it was obvious that the positive effect of the beach dewatering could constitute a soft measure for restoration of eroding beaches. Modelling tests, full-scale controlled prototype and commercial beach drainage facilities have shown that it would have been short-sighted to neglect the observed effect of the salt water intake at Hirtshals West.

Acknowledgements

I would like to thank the following contributors for their input into this newsletter:

Hans Vesterby; Prof. Jordi Raventos; Dr Heidi Shaw; Dr Carlota Montori; Carl Linderoth; Karsten Mangor; Roberto Rossetti; Steve Burstow; Dr Richard Weisman; Torsten Knoblauch; Dr Rozlan Taha; Bob French.

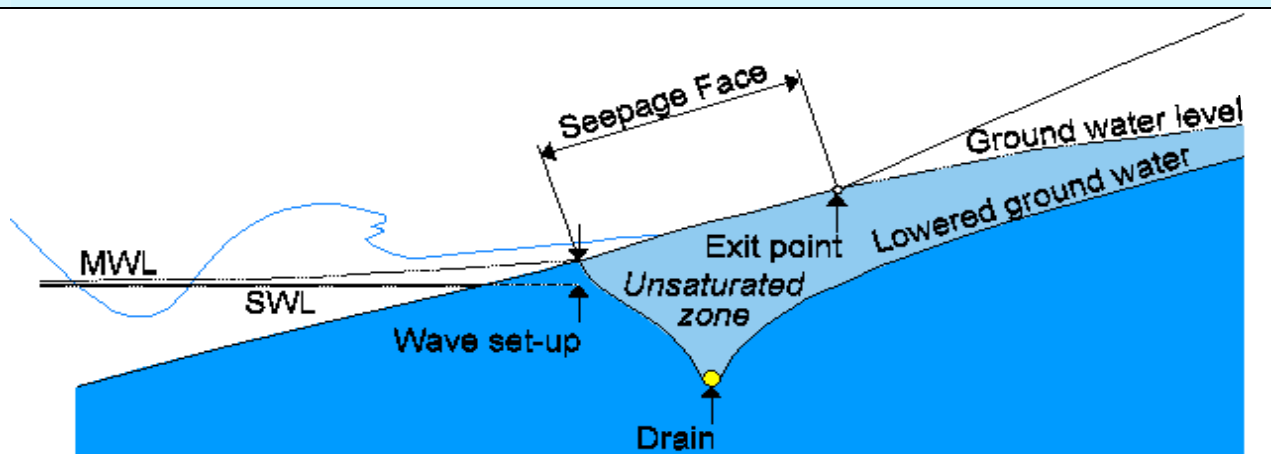
A Beginners Guide to BD – A soft engineering solution to soft shore erosion

Beach drainage or 'beach face dewatering' (BD) involves the localized lowering of the water table beneath and parallel to the beach face. This has been demonstrated to cause accretion of sand above the installed drainage system. Sand is in continual movement on a wet beach face due to wave and tidal action in the 'swash' zone. Under specific conditions, beach drainage systems can halt beach erosion and promote sand accretion by adjusting the dynamic equilibrium that exists on sand beaches.

The accretion or erosion of a beach is influenced by a number of hydrodynamic forces in a beach surf zone. The effects and interaction of these sediment transport mechanisms have been studied since the 1940's. It is well understood that lowering the water table in granular soils improves their stability and eliminates the tendency for them to move (ie, 'well-pointing'). A number of theories have been proposed to explain the empirical evidence for sand deposition from beach drainage (ie, backwash reduction, seepage reduction, liquefaction reduction). These and other theories continue to be studied around the world expanding our understanding of the complex interplay of forces that can be seen working on the beach face.

It is evident that lowering the water table under the beach eliminates buoyancy factors and reduces the lubricating effect between the grains, restoring the frictional characteristics of the sand. Percolation of 'swash water' into the beach means less backwash energy, which encourages suspended sand to settle out on the beach face.

This is achieved by installing a drainage system in the beach that lowers the beach face water table, intercepting the flow of swash, tidal and inland ground water. Collection pipes are buried in the beach parallel to the coastline to create an unsaturated zone beneath the beach face. This unsaturated zone is achieved by draining the seawater away by gravity to a collector sump and pumping station. The sump and buried pumping station can be located at the back of the beach, where they are not readily visible. A typical pumping station might consist of two submersible electric pumps located in a buried concrete chamber. The only visible feature of the system may be the pump station control panel that regulates and monitors the pumps, sends data and receives control signals.



A useful side effect of the system is that the collected seawater is very pure because of the sand filtration effect. It may be discharged back to sea but can also be used to oxygenate stagnant inland lagoons /marinas or used as feed for heat pumps, desalination plants, land-based aquaculture, aquariums or seawater swimming pools.

Beach drainage systems have been installed in many locations around the world to halt and reverse erosion trends in sand beaches. 25 BD systems have been installed since 1981 in Denmark, USA, UK, Japan, Spain, Sweden, France, Italy and Malaysia with 5 more under construction or approved for installation in 2003-4.

The potential advantages of a beach drainage system include,

- the discreet nature and minimal environmental impact of the operating system compared with nourishment or existing hard engineering solutions
- provision of a buffer zone from storm events and seasonal erosion and improved recovery time to pre-storm equilibrium following storm events
- improved amenity value for recreational beaches by increasing the available high tide beach width /height and providing a dry beach surface between the tides
- natural dune growth and rehabilitation will be encouraged adjacent to the installed system due to the increased availability of wind blown sand
- protection of coastal fresh water environments from sea 'over-topping' and seepage contamination
- better 'natural character' outcomes than hard engineering or nourishment
- a gentle form of sand replenishment - the risk of reef and beach habitat damage from nourishment activities is eliminated
- the cost per meter of coastal protection (CAPEX & OPEX) can be much lower than other solutions but this is dependent on system length and other cost sensitive factors
- the system may offer an easier route through local environmental consent & permitting procedures.

For a full version of this BD Technology Introduction document please contact t.richards@bigfoot.com

For further information on BD activities in your region, please contact your nearest BD proponent.