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Assessing, packing and moving Natural Science collections to new stores:Case study -Planning the relocation of the Natural Science collections stored at the Museum Resource Centre in Ryegate Road, Colchester.




Contents

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1 The environmental conditions required for natural history collections

Temperature and relative humidity

British Standard 5454 (Recommendations for the storage and exhibition of archival documents (re the MLA's Benchmarks for Collection Care)) used to dictate that environmental conditions for archive and museum collections should be 50% RH +/-2%, and 19˚C +/- 1˚C.This was withdrawn in March 2012 and replaced with 'PD 5454:2012 Guide for the storage and exhibition of archival materials' and 'PAS 198:2012 Specification for managing environmental conditions for cultural collections'. These two documents reflect the changes in policy called for by the National Museum Directors Conference in 2009 aftercultural heritage institutions were asked to reduce their reliance on fossil fuels while meeting their responsibility to preserve collections. The NMDC adjusted their own environmental guidelines to a much broader range of 40-60% RH and 16-25˚C in an attempt to reduce energy consumption by these institutions, with the caveat that materials of particular sensitivity could be catered for by creating small stores or microclimates providing conditions suitable to their needs.

Obviously, it is wide and regular fluctuations in environmental conditions (even within the parameters above) that generally cause stress and therefore damage to specimens (e.g. subfossil bone, ivory and teeth splitting; clays delaminating; soluble salts effloresc ing etc), rather than being near one of the limits with gentle changes. Stability is the key goal, though some material reacts at extremes of the prescribed ranges, see below. Also, at high humidities mould growth can occur and insect pests become more common, as with higher temperatures. No collections are immune to insect damage: packing materials and labels can be attacked and consumed (the loss of the latter can be disastrous). Higher temperatures can cause consolidants and adhesives to slowly weaken and fail.

Conservators specialising in the care of geological material advise that general geological and palaeontological material should be stored with minimal daily fluctuations at around 15 to 25 ˚C and, more importantly, 45% to 50 % RH - maybe even 55% as an upper limit but 60% and above even a couple of times a year should be regarded as a failure as this may well trigger pyrite decay. At above 70% there is also a risk of mould growth. If subfossil material is present in the collection, especially ivory and mammoth teeth, then RH as low as 40% may cause it to crack, along with some clays of various ages that may contain fossil specimens.

For general natural history collections containing a wide variety of material, the ideal storage temperature would be between about 13 to 18˚C all year. This is mostly lower than would generally be comfortable for people trying to work in the collections (for which 16-18˚C is recommended). Active cooling is expensive, so the practical solution is to provide as low a temperature as the institution can afford whilst not making it impossible for workers to spend time in the collection area.

The relative humidity should not exceed 60% nor fall below 45% but the most important requirement is to avoid fluctuations, especially rapid and extreme fluctuations "*Temperature*

is important primarily for its direct effect on RH. It is generally set for human comfort within set (often legal) limits. It is also significant when considering the consolidants and adhesives which have been used. When heated to their glass transition temperature they become much softer, considerably weaker and dust will stick to their surface. At lower temperatures they often become brittle. For composites such as mounted specimens where fossil, steel and fibreglass, etc are all combined, fluctuating temperatures will create stresses due to the different coefficients of expansion of the components. The rates of chemical reactions are controlled by temperature so chemical degradation processes will be accelerated at higher temperatures" Fitzgerald 1995 (page 119).

For all these reasons it is important not only to understand what parts of your collection require a higher humidity and which parts require a lower humidity but also to know which parts of your storage areas provide the optimum conditions for these sub-collections. Not only will conditions vary from store to store but even within a store, depending on which walls are internal or external, and on the positioning of hot water pipes, radiators and vents etc.

Temperature has a direct effect on pest infestation and reproduction, so the right temperature settings can be used to reduce and even largely eliminate pest damage. Pinniger and Meyer (2001) state "*Warm temperatures of 20°C and above will encourage insect breeding*".In 'The Care and Conservation of Natural History Collections' (edited by Carter & Walker) on pages 144 to 145it states "*Wherever possible a cooler environment would be beneficial to specimens (the higher the temperature, the higher the rate of damaging biological activity and chemical reactions). It is recommended that unoccupied stores could be maintained at 13 to 15 degrees C. ...Fluid preserved specimens particularly benefit from cooler conditions. It reduces evaporation and the rate at which specimens deteriorate*".On page 165 it is stated"*Collections storage areas should be kept as cool as practically and economically possible. Temperatures lower than 20 degrees C should slow insect growth considerably. Below 15 degrees C should eliminate insect problems".* In addition Carter & Walker state (on page 137) that low temperatures help to preserve DNA in natural history specimens.

If the environment of a collections area is less than ideal, it may be ameliorated to an extent with a dehumidifier. However, a dehumidifier in a large storeroom may be battling against the odds, especially if there is a large rate of air exchange. Often dehumidifiers are not emptied of water frequently enough, or an assumption is made that because there is a dehumidifier in place then all must be well. As well as sometimes doing little to reduce RH they may sometimes lead to a lower RH than you may want. The key to maintaining a good storage environment is not just monitoring all areas effectively (spending money on more environmental dataloggers is always money well spent, especially as there are often environmental gradients within a room) but reading, correctly interpreting and acting upon the environmental information recorded is absolutely crucial. The environment of each collection storage area should be reviewed every month, and all the data looked at collectively every quarter, looking each time at the last 12 months' worth of data. It is vitally important, however, that all monitoring equipment is calibrated and consistent or the results will be open to misinterpretation.

Once the peculiarities of an individual collections storage area are well understood then the collections can be rearranged suitably, taking into account the guidelines above: pyritic geological specimens prone to decay should be stored together in areas that are stable and have a lower RH, and subfossil material (especially tusk, ivory, mammoth teeth *etc*) and osteological specimens can be stored in an area that is similarly stable but has a higher RH

on average (but still within the parameters suggested above). Fluid specimens require cooler conditions. Other material – the bulk of the collection - can be stored in the middle ground. Storage areas can be further controlled by the intelligent use of dehumidifiers and radiators, preferably controlled by humidistats (particularly in the winter). These can be plugged into a socket in the wall, the parameters set accordingly and the radiator or dehumidifier plugged in to it. If an area of a storage room needs to be boarded-off with wooden panelling to make a smaller area more controllable this is money well spent – such a job may take just a day or two. Possibly longer if lighting needs to be adjusted.

Air quality.Ideally, incoming air would be filtered to remove gaseous pollutants (sulphur dioxide, nitrogen dioxide, ozone and hydrogen sulphide if the air outside the museum is considered to be of poor quality.

Light levels. Specimens vary so much that maximum light levels are difficult to state, other than to say that daylight should be avoided or kept to an absolute minimum as ultra violet is deleterious to specimens and in particular to any materials added to them, e.g. organic consolidants and adhesives. Light sensitive specimens such as ivory, fluid-preserved material, mammal and bird skins etc should be stored in the dark and should be exposed to no more than 150 lux, and even non-sensitive specimens on display should be exposed to no more than 500 lux (Fitzgerald, 1995)due to likely local heating effects. It should be remembered that consolidants and adhesives will degrade under light and heat more readily than the specimen and this can lead to mechanical failure of the specimen.

Building maintenance.All the hard work described above is completely undone if gutters, downpipes, overflows and storm drains etc are not properly maintained and cleaned regularly. You cannot rely on a separate estate management department saying that this has been done or will be done regularly (especially when departmental budgets are being cut). You will have to take responsibility for checking this yourself as much as you are able – especially if building work is underway on the premises. It may take only one relatively minor incident to completely saturate a wall and it could take months to dry out properly, with potentially disastrous consequences for specimens (Cornish et al, 1995; Andrew, 1999). If you do not anticipate this in advance, you may not know the process is underway for a couple of months, depending on how good your environmental recording is and how often you analyse the data.

References for the above section:

Andrew, K. J. 1999. Conservation of the Whitby Saurians – Large Scale, on Site Geological Conservation in North Yorkshire, United Kingdom.*Journal of the Canadian Association for Conservation (*J. CAC), Volume 24.

Carter, A. & Walker, D. (Eds) 1998.The Care and Conservation of Natural History Collections (Conservation and Museology series).Butterworth-Heinemann.

Cornish, L., Doyle, A. &Swannell, J. 1995. The gallery 30 project: Conservation of a collection of fossil marine reptiles. *The Conservator*, Volume 19 Issue 1 1995.

Fitzgerald, G. R. 1995. Storage and Transport.In The Care and Conservation of Palaeontological Material, edited by Chris Collins.Butterworth-Heinemann.

Pinniger, D. B. & Meyer, A. 2001.Pest Management in Museums, Archives and Historic Houses.Archetype Publications Ltd.

2 The general pros and cons of movinga natural history collection to a new store

If an alternative building to the current stores has not yet been identified it is impossible to come to a conclusion about such a move. However, the comments below should help to frame such proposals in due course.

Pros

- If being moved into much better environmental conditions (seeabove) the collection will benefit in the long term, as long as the move itself does not endanger the specimens.
- If being moved into a much better environment in regards to Integrated Pest Management (i.e. the building is totally secure and guttering, downpipes and storm drain all function perfectly and are inspected and maintained; windows are sealed; an IPM plan is in place and pest monitoring is underway and conditions are found to be good before the move; etc.) then the collection would benefit in the long term.
- If the necessary funding is found to greatly improve the documentation of the collection before the move as part of the overall project then the collections and the museum service will benefit in the long term (if the whole collection is adequately documented and the information is made available online then the collection is much more accessible to stakeholders (internal and external) as well as staff, and will be used more).
- If better storage furniture is provided the collections will benefit in the long term.
- The new storage area must have at least as much space as it has now: including any lab or study areas and/or library.

All of the above 'Pros' come with two caveats:1: 'As long as the move itself does not physically endanger specimens' should be added to each of the 'Pros'. 2: It must not be the case than only one single 'Pro' is achieved for the move to be considered worthwhile, most of the conditions above would have to be fulfilled for the move to be considered worth the risk.

Cons

- If not being moved into much better environmental conditions (see above) the long term future of the collection is at grave risk.
- If not moving into a much better environment in regards to Integrated Pest Management the long term future of the collection is at grave risk.
- If the collection is moved without adequate documentation being undertaken first, not only is the long term future of some of the collection at risk from the context of specimens being lost, but it will be an opportunity wasted. If the collection is not already documented and available online then thecollection will simply remain invisible to most external stakeholders and will remain underused by staff as long as the documentation is not improved. Therefore the collection will be under threat of neglect and even ultimately of disposal. As all the specimens will be handled if being moved this is a good opportunity to document themat the same time if resources allow.
- If the collection is moved to a geographical area not as accessible as the current store (i.e. much further away from the museum; nowhere near public transport stops; without adequate parking; up several flights of stairs; etc) it will become less used and may be under threat from neglect.

- If the more decrepit storage furniture remains the same and is not replaced this reduces the accessibility of the collection and the cabinets will continue to deteriorate and malfunction further.

3Packing, moving and unpacking natural history collections in general

When deciding how to pack, move and unpack any natural history collection several things must be taken into consideration:

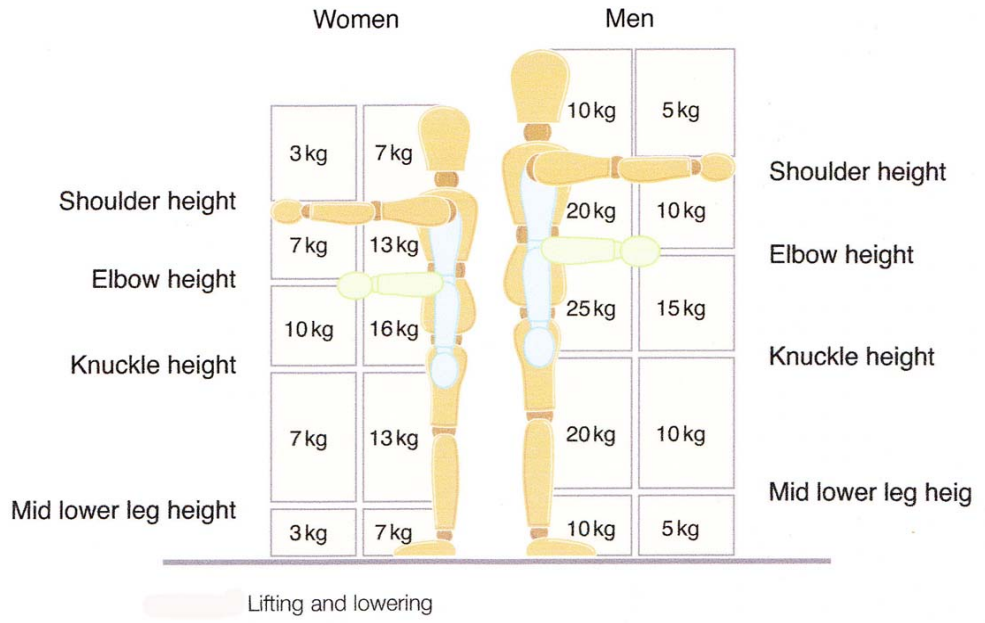
- You ***must*** know well in advance of organising the packing of the collection the exact details of the storage furniture that will be used in the new store as this will affect how you approach packing your collections. If new cabinets with drawers are to be used, it would be very useful to order the drawers in advance and pack all your material into these new drawers in an orderly fashion before the move itself, making the move run more smoothly and reducing the movement of dirt and pests into the new store. If no new storage furniture will be ordered and you will simply be using the existing drawered cabinets then you can pack up the drawers as they currently are (assuming they are not too heavy) - undertaking all relevant labelling, bagging-up and documentation as required (including giving unique numbers to all cabinet carcasses as well as their drawers). If roller racking is to be used in the new stores to save space, check the size of the racking being ordered and compare it to the sizes of your various cabinets currently in use to make sure they will fit on to the new mobile racking system if that is the intention.

Left: Manually powered scissorjack lifting table. Right: Electric stacker.

- Wherever possible, mechanical handling should be used to move cabinets and/or specimens to reduce risks to both staff and specimens. Electric or manually pumped stackers or scissor-jack trolleys are a very good investment when compared to the costs of staff being off work due to back problems or due to serious or even relatively minor accidents. Old stores were rarely planned sensibly with ergonomics or health and safety legislation in mind. Getting individual heavy objects off shelves or full drawers out of cabinets is risky enough, but if a whole store is being moved, doing

this repeatedly will take its toll unless suitable mechanical devices are used -See figures above and below for suggestions. Note: check the width and turning circle of the stackers, scissorjack table and/or trolleys you are considering purchasing and measure the aisles in your store, and any doorways or lifts you'll need to use. Check you'll be able to use the equipment in the all spaces available.

- The new stores must be planned ergonomically. Will the stores rely on mechanical handling (and if so will the mechanical handling equipment be reliable, and is there a budget for maintaining it?) or will it rely solely on manual handling? If the latter, the following diagram is useful and will help you plan how the new store should be populated with specimens based on their weight. Even if mechanical handling is going to be used, it would be best to follow these guidelines wherever possible as mechanical equipment often isn't as available as it was planned to be.



Lifting and lowering

- Once material has been taken off shelves safely, damage can still be inflicted on natural history specimens if inappropriate trolleys are used to move the specimens around the store, along corridors, into loading bay areas and ontolorries or vans. Many trolleys have hard polypropylene wheels that do nothing at all to absorb the shock and tremors resulting from running over even a relatively smooth surface. If they roll over rough concrete the shocks can be considerably damaging. The best sort of trolley to use for natural history specimens is one with large pneumatic tyres, like the one below.

- All specimen boxes, trays and drawers ***must*** be kept flat, never tilted. Otherwise the contents can become completely muddled and will also be at risk of breakage.

- At the start of the project all staff and volunteers who will be packing and moving material should be given a training course covering the correct way to lift and move specimens and boxes not just for health and safety reasons to reduce injury and strains but to make sure everyone understand that all boxed specimens must be kept flat and never tilted, and also that they fully understand the chosen system of labelling, documentation and packing that must be rigidly and consistently adhered to.

- There must be a budget for providing steel toe capped shoes or boots for all people moving the collection.

- Integrated Pest Management policy: In an ideal world, the entire collection would be frozen cabinet by cabinet during the process of being transferred to the new stores so that no existing pests are transferred to the new (presumably pest-free) facility. If specimens cannot be frozen at the existing store or at the new site, some museums – such as Ipswich - offer such facilities. However, this may require much further transport by road, so material would be at additional risk from vibrations and accidents whilst in transit and time will be added to the project. Alternatively, a quarantine area could be set up at the new stores where a temporary freezer could be installed and incoming material could be frozen as appropriate before being put into the new collections area.

- All cardboard boxes containing natural history material should be taped up securely, using parcel tape liberally along all seams so that it is not easy for insects to crawl into a box. In addition, putting boxes on pallets not only raises them off the floor and makes it slightly more difficult for insects but also offers some protection in case of flooding. If time and money is available, the boxes containing particularly vulnerable collections could be wrapped in thick polythene and taped. This will also provide a partial barrier to climatic fluctuations – but make sure the wrapping is not undertaken on a humid or wet day.

- Before moving any of the collection to the new stores, the building must be thoroughly assessed and if need be improved: Gutters, storm drains and downpipes must all be in perfect working order and measures must be in place to prevent them

from becoming blocked, including at least an annual inspection and maintenance. All windows, chimneys and old vents must be well sealed, and if there is ventilation taking air from outside the building, suitable filters should be in place.

- Make absolutely sure that the floor loading capability of each store has been definitively established and is proven to be acceptable for your planned use.

- If you plan to use your old cabinets, look at them carefully at the earliest opportunity: some may have been purpose-built in the store and may not fit through the door or into a lift. The cabinet may not be dismantled easily as they tend to be glued and screwed, not just screwed.

- Whilst planning your project and long before actually packing-up specimens, assess all hazards and undertake a full written risk assessment to establish the main risks to your collection as well as staff and volunteers etc from each separate process in your project. Look for the signs of potential hazards, plan and prioritise how you will manage the hazards you have identified, and share your plans with colleagues. Establish good working practices and seek specialist advice if you need it.

- Bear in mind extra insurance may be required for the transportation of your specimens

4 **Hazards specific to Natural History Collections**(this list is ***not***exhaustive – consult your local conservation team)

Apart from the obvious physical hazards posed by lifting and moving not just heavy items but by lifting and moving lots of items, there are quite specific, subtle, and invisible risks relating to packing and moving natural history collections that must be understood and taken seriously. The risks are high enough that specific health and safety legislation is in place covering many areas. The chemical, biological and mineral hazards in natural history collections pose a risk to people mainly because they can be absorbed by the body in a variety of ways.

Inhalation: Surface deposits of toxic chemicals and hazardous dusts or mould can be breathed in, especially when objects are being handled or cleaned. Damaged, aged and crumbly materials, such as old asbestos, can be very problematic. Some materials give off gases as they age which can also be inhaled. It is also possible to inhale radioactive dust and to swallow contaminated food or water.

Absorption through the skin: Some materials will pass through the skin when objects are touched and enter the blood stream. The sticky residues from degrading plastics and leaking fluid from preserved collections are examples. Chemical residues such as naphalene in moth balls can enter the body in the same way. Radioactive sources, such as naturally occurring mineral specimens, emit radiation which is able to pass through the skin. Storage materials, such as tissue paper and boxes, can absorb radiation, acidic vapours and pesticide residues, adding to the hazard.

Ingestion: Handling objects and then handling food or touching your face/mouth with

unwashed hands can lead to potentially dangerous materials being swallowed. Dormant diseases which can be present within human and animal remains can be reactivated if dust or other debris is breathed in or swallowed.

Richards (1994) presents a useful overview of health and safety issues and procedures relating to natural history collections.

N.B. Anyone who is pregnant, or who thinks they might be pregnant, should simply not work in a natural history store, and certainly should not move specimens or pack them.

4.1 Radiation: Some geological specimens are naturally radioactive. Minerals, rocks and fossils containingpitchblende, thorium,torbernite, metatorbernite, autuniteuranium, uraniniteor other uranium oxides, either as an essential constituent or an impurity, emit hazardous ionising radiation (uraninite is the most radioactive ore of uranium). They must be identified and managed to comply with the Ionising Radiation Regulations (1999) (known as IRR99) and other national laws in England. Each institution needs to establish procedures and rules for safe detection, handling, use, storage and disposal of its radioactive holdings. These can include the designation and training of radiation workers, the establishment of a secure controlled storage area for the 'hottest' specimens.

Before you start to pack your geology collection, check your database to see if there is any mention of radioactive specimens, or any of the specimens listed above. If you have any such specimens do not panic. It is easy to worry too much about radioactive specimens. As long as you know where they are and you ensure no-one is working near them day-in, day-out, they are not usually a problem.The Ionising Radiation Regulations 1999 gives guidelines as to how material is to be safely worked with, such asreducing the handling of them and keeping them away from public areas, offices and workrooms.The most important thing is to make sure that no-one can inhale or ingest radioactive dust. Radioactivespecimens should be well packaged e.g. in sealed bags, well labelled, with radiation stickers on the outside of the boxes or drawers and the issue must be recorded on your database. Radioactive specimens can be kept together in an area of a store which is not visitedoften, although this can increase the local levels of radiation in which case reduce thedensity of storage to prevent this. Lead-lined boxes can reduce or eliminate the hazardalthough radon gas can build up so move away from the box when first opened and do notbreath in over it. This will allow the radon gas to disperse. The radiation hazard can be reduced if the specimen is at least stored withina closed cabinet. This will absorb some of the radioactivity. It can even help to putspecimens at the back of drawers.Any storage cabinet they are stored in must be ventilated so that radon gas does not build up. For collections with significant numbers of radioactive specimens (exceeding half adozen or so) consider segregating into a controlled radiation area. This should includeextract-ventilation to remove the built up of highly toxic radon gas. Ventilation should beto an exterior wall. Obviously disposable dust masks and gloves should be worn when handling the specimens and their containers and these should be put in a sealed bag and disposed of in the relevant fashion afterwards.

It is the unknown specimens that are a problem. Use a beta radiation Geigercounter/gamma-ray dose rate meter to detect radioactivity in your stores - check the radiation levels of each cabinet or crate. The upper limit is presently set at: 7.5 μSv per hour. This level is not likely to occur under normal conditions. Ask for help from a Radiation Protection Advisor working in your local authority, or the National Radiological Protection Board. You may find a Radiation Protection Advisor in your local hospital or in the engineering or geology

department of your local University (where they may be called a Radiation Protection Supervisor).

For more information, see Jan Freedman's article 'Storage of the radioactive mineral collections at Plymouth City Museum and Art Gallery, UK' in 'Collections – A Journal for Museum and Archives Professionals', Volume 7, no 2, 201-213, 2011. You can email him for a copy at: Jan.freedman@plymouth.gov.uk

4.2 Asbestos:
Anyone handling asbestos specimens should have had asbestos awareness training and also training in handling asbestos samples. ***This is law and not optional.*** Talk to your institution's health and safety rep/officer or relevant department at the earliest opportunity to find out what courses are available – or contract the work out to a commercial asbestos handling company.
Asbestos is a naturally occurring hazardous substance.Fibrous asbestos minerals are recognised human carcinogens and no safe level of exposure is acceptable. Being aware of what might be, or is, asbestos and how it should be handled and managed is essential for (and a legal requirement of) all those in contact with geological collections. In law (Control of Asbestos 2012) asbestos is defined as the fibrous form of the amphiboles actinolite, tremolite, grunerite, anthophyllite, Amesiteand crocidolite, as well as chrysotile, a fibrous serpentine group mineral. Not included within the legislation are other fibrous minerals that medical research suggests may be potentially hazardousand these also need to be evaluated and managed:Brucite; nemalite (this is brucitepseudomorphingtremolite, so residual fibrous tremolite may be present); Richterite; winchite; and Erionite (zeolite) - not commercially exploited but more carcinogenic than crocidolite. Fibrous forms of the following have no proven link to mesotheliomas in epidemiological studies but are suspected on their fibre make up and chemistry: Wollastonite; Palygorskite (attapullgite); and Sepiolite.

A useful reference is: Wagner, J.C. et al, 1985. Erionite exposure and esothilomas in rats. British Jl. Cancer, 51, 727-730.Asbestos and other natural mineral fibres, World Health Organisation, 1986.

Synonyms for asbestos minerals – check if any of these are in your collection:

Actinolite: Attinoto, byssolite, stibolite, stralite, strahlenstein, zillertite/zillerthite, manganactinolite, ferro-tremolite.
Tremolite: Raphilite, sebesite, calamite, peponite, grammatite, abhabite, abkhazite,Grammatit-Strahlstein, heepfnerite, kalmite, nordenskiöldite, raphilite, smaragditic, TonerdehaltigerStrahlstein.
Anthophyllite: Anthogammite, grey asbestos, kupferite, antholith, trelite, thalacerite, antholite, anthophylline, magnesio-anthophyllite.
Crocidolite: Abrichanite, blue ironstone, cape blue, varmanagan-crocidolite, mangan-krokidolith, (riebeckite) – osannite, orthoriebeckite, abriachanite.
Chrysotile: Bostonite, kuphoite, kupholite, picrosmine/pikrosmin, schweizerite, amianthus, Syn asbestos, asbophite, bostonite, faserserpentine, lefkasbestos, karystilite var. scheizerite, metaxite, proidesine, marmolite, retinalite, thermophyllite, batite, vorhauserite.
Grunerite: AmositeLydenburg&Pietesburg Districts, Transvaal, RSA. Amosa Asbestos Mine, (Asbestos Mines of South Africa) (original material actinolite&cumingtonite). Used for asbestiformgrunerite-cummingtonite

The poor quality asbestiformfibres of amphiboles are called byssolite, or brittle asbestos.

Treat any fibrous mineral with suspicion. Check your collection database to see if there is any mention of these specimens before you start to pack your geology collection. Bear in mind

that specimens cannot be disposed of without following strict proceduresinvolveing licences/permits.

The most important thing is to make sure that no-one can inhale or ingest any fine particles or fibres from these specimens.When handling, remember thatasbestos minerals are very fibrous and fragments are easily broken off, and always wear a mask, gloves and lab coat. The specimens should be well packaged e.g. in sealed bags(two layers for safety), well labelled, externally marking packaging as containing hazardous material i.e.with appropriate hazard stickers on the outside of the boxes or drawers. Record the issue on your database.

All dust associated with the specimen and created during packing should be cleaned up with a specialist vacuum cleaner with appropriate filters – in fact by a specialist asbestos removal company.There are regulations covering the control of asbestos. Contact your health and safety officer who will be able to advise you. In most cases the rule is to eliminate direct contact and the build-up of dust.

Transporting asbestos specimens: Technically, if asbestos specimens (suitably double-bagged and labelled appropriately) are transported from one of your sites to another of your sites then no permit is required. But if they are transported from your site to somewhere that is not your site then a permit/licence is required.

4.3 Other toxic minerals: There are no minerals which are so toxic that normal handling will produce dramatic poisoning**,** however some are very toxic by ingestion or inhalation.Minerals that are moderately to highly toxic if ingestedinclude:antimony; bismuth; boron; arsenic (especially claudetite, arsenolite and orpiment); Fluorine (any soluble fluoride mineral); bornite; cerussite (lead); Barium(witherite, nitrobarite, barite, frankdicksonite; malachite (copper); mercury; quartz; vanadate; galena (lead); Leadarsenates, carbonates, chlorides, oxides, phosphates and sulphates; chalcopyrite (copper); zinc; Selenium; Thallium; and cinnabar (mercury) – this last one can give off toxic vapour. Acute poisoning is very unlikely although arsenic, lead, mercury and thallium minerals should be regarded as highly toxic. Arsenic and its compounds are considered carcinogenic. The lethal dose from arsenic can be as low as 20mg. The lethal dose for thallium as the oxide is 100 to200mg for an adult.

All the minerals mentioned above should be handled only when wearing suitable disposable gloves and dustmasks. They should be sealed in bags or containers with secure lids and should be clearly marked with the conventional hazard symbols. They should not be left where people would be able to handle them freely. It is safest to assume that allunidentified mineral specimens are toxic if ingested or inhaled. Not eating or drinking in thevicinity of geological collections is common sense, as is the wearing of disposable gloves at all times. All mineral dust is harmful if inhaled.

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Other minerals may be hazardous due to their physical nature, as they may have sharp edges or are fibrous: these can include fibrous zeolites, fibrous forms of amphiboles (tremolite or actinolite), pectolite, epidote, okenite and scholzite. However, any mineral which has a sharp surface can be potentially hazardous. Skin contact with some minerals can cause irritation. Theseinclude: petroleum oil, bitumen, and other hydrocarbons.Mineral dustscan also be a problem, especially when preparing specimens in a lab. These include quartz, olivine, magnetite and talc, or minerals which contain beryllium, cadmium, iron oxide, manganese, vanadium, chromium or nickel.

Precautions: Wear gloves, (preferably thick rubber). It is always best to treat any fibrous minerals with care (and best not to handle at all as this may also damage the specimen). In general, use common sense and observe any potential physical hazards that may exist. As a rule try to avoid inhaling any dust.Wear masks when working in dusty conditions. Try to

keep areas where dust is generated well ventilated (especially when cutting, grinding or polishing minerals).

4.4 Fluid-preserved specimens: Specimens preserved in fluid in glass jars will be fragile and should be moved extremely carefully to avoid damage. The use of trolleys with soft pneumatic tyres is essential, and as specimens in fluid can be very heavy do not try to move too much at once, to avoid both injury and accidents. Larger specimens may require specialist mechanical lifting equipment. Bear in mind some jars may be very old and brittle. In addition there are very specific health and safety issues surrounding these collections as the fluids involved are often toxic and/or flammable. Although molecular biologists store samples of animal and plant DNA in absolute ethanol, most whole specimens are stored in 70-80% IMS (industrial methylated spirit) which dehydrates them and maintains their state of preservation so that they do not deteriorate. Such specimens are usually stored in glass jars in a cool temperature (about 10 degrees Centigrade) and in the dark. Provided that this state is maintained they can last indefinitely. Maintaining them can be a problem:

- Formaldehyde which is used as a fixative (initial preserving agent) is poisonous and dermatitic, its fumes are highly irritating and carcinogenic
- Formalin is non-flammable but toxic, an irritant and a carcinogen but comprises an essential primary stage for tissue preservation.
- Alcohol (Industrial methylated spirit or IMS) is a mild irritant, its vapour canbecome explosive in high temperature and it is flammable.
- Other preservatives may have non-hazardous vapour but many are stilltoxic, so all preservatives require careful handling. Surgical gloves and facialprotection must be worn, and fume extraction facilities should be used. Present nearby should be eye-washes and fireextinguishers: foam and CO2.Preservative fluids are regulated under COSHH, (Control of SubstancesHazardous to Health regulations).Specimens are often stored in various types of glass jars and some cannotbe stored in anything else if the preservative has a solvent effect onplastics.
- If moving specimens preserved in fluid/spirit, a spill kit must be available and training must be given that is appropriate to the fluids involved.

Only trained staff should move fluid-preserved specimens (Simon Moore runs courses on fluid-preserved specimens regularly. His email address is: Couteaufin@btinternet.com). Always wear goggles and labcoats or aprons. When moving larger specimens, wear a leather apron and leather wrist and forearm guards. If topping-up specimens before a move (which is recommended, as if there is not enough fluid the specimen is more vulnerable) be very careful when opening jars: lids should be released slowly to prevent the rapid escape of accumulated vapours which could be toxic or explosive. For this reason it should be undertaken in a (preferable spark-proof) fume cupboard, or near other suitable extraction. Do not work with fluid-preserved specimens for more than two hours at a time, to reduce exposure to vapours. Do not work alone but in pairs. Be aware of your policy for dealing with spillages and know where your spill kit is – larger spills will require breathing apparatus. Ensure appropriate fire extinguishers are nearby: carbon dioxide, dry chemical powder or appropriate foam.

New shelving must be sturdy enough to take the considerable weight and to withstand spillages. Storage containers must not allow the loss of fluids or vapour. Where the preservatives are flammable the collection should be housed in a structure with a fire retention value of no less than one hour. Where possible, the area around spirit stores should be bonded so as to contain corrosive and flammable liquid in the event of spillage (Howie, 1989).

Info re the transport of fluid-preserved specimens to go here

Useful publications regarding fluid-preserved collections include:

Clark, Crimmen, Naggs, Wahl and Mansfield. 1994. "*Transportation of fluid-preserved natural history specimens stored in glass containers: new Solutions to an old problem*". The Society for the Preservation of Natural History Collections, Collection Forum, Spring 1994, volume 10, number 1.

Horie, C V (Ed.) 1989.*Conservation of Natural History Specimens, Spirit collections.* Manchester University and Museum,

Howie, F M P. 1989. *Health and safety considerations.* In Conservation of natural history specimens: spirit collections, Manchester University and Museum.

Moore, S J "*Fluid Preservation"* in *Care & Conservation of Natural History Collections.*Eds Carter & Walker, Butterworth-Heinemann, 1999.Museums & Galleries Commission, *Standards in the Museum Care ofBiological Collections.*1992.

Rose, C L & de Torres, A R, *Storage of Natural History Collections: Ideas & Practical Solutions.*Society for the Preservation of Natural History Collections (SPNHC), USA,1995.

4.5 Insecticides/pesticides: Historical pesticides are frequently found on 'skins'(of fur and feather) and on old taxidermy specimens but can also be found on ethnographicobjects containing fur, hair and/or feathers, as well as some textiles. The products used may include DDT,arsenic or mercuric chloride - or a mixture of these and other compounds. They were used for 200 years toprevent or reduce insect damage until the late 1970s, so are present in most museum collections.Most have now been banned as although they killed or deterred insects they were found to be deleterious to human health as well. For this reason all 'skins', all taxidermied birds and other 'stuffed' animals as well as ethnographic artefacts containing these materials should be handled as if they were known to contain harmful pesticides. Therefore goggles, disposable gloves and dustmaks should be worn at all times when handling such material and specialist vacuum cleaners with fine particle filters should be employed whilst packing specimens and for cleaning the area afterwards. It is best practice to do all the handling and packing in the same area, keeping it scrupulously clean and of course eating and drinking nothing in this area or whilst working with this material.

Pesticides can also be found in botany collections, specifically herbarium mount sheets: arsenic, mercury, lead, barium and naphthalene have all been used. The amounts involved are not necessarily acutely dangerously high, but they could be significant with prolonged or repeated exposure. The levels are certainly significant enough to warrant minimising the risk through implementing safe working practices such as wearing disposable gloves and dustmasks when handling the specimens; sealing-up boxes containing them if they are being moved; and cleaning the work are area frequently with a specialist vacuum cleanerwith a fine particle filters.

Even drawers, boxes and cabinets empty of specimens should be treated with caution. The organochlorines DDT and Lindane were sometimes used as a powder and simply scattered about in drawers and containers and sometimes on open shelves. Large residues of these substances still remain in some collections so caution needs to be exercised when opening or moving old boxes, cabinets and drawers. If being emptied and/or moved, all storage furniture should be cleaned of all dust and debris with a specialist vacuum cleaner that has a fine particle filter.

Naphthalene was commonly used in natural history collections, for instance in drawers of study skins. However, it is no longer supported as a pesticide as no safe level has been set andthe occupational exposure standard has been withdrawn.It is now classified as a suspected carcinogen. Even low levels of exposure can cause severe haemolytic anaemia in susceptible individuals and kidney failure in others (Richards, 1994).

Be aware that in some areas there may be higher concentrations of chemicals than others. Lifting the lid of a sealed unit (such as a polypropylene 'Stewart Box') containing even a relatively small amount of pesticide may briefly produce a higher concentration of fumes than anticipated. The dust of recrystallised pesticides and fumigant residues can enter the body unnoticed through skin contact so gloves should be worn at all times during packing, when dust is disturbed. Bear in mind that it is not just through the hands that these substances can enter the body: mucous membranes and eyes absorb chemicals as well, so be wary of dust clouds being created when moving and packing specimens, or when moving boxes or cabinets. Constant vigilance with a vacuum cleaner with appropriate filters is necessary.

Old collections can be tested for harmful chemicals using spot-tests such as those advocated by Found and Hedwig (1995).

4.6 Other issues:

***Bones*:** Osteological specimens present no special problems unless they are from freshly defleshed carcasses. However, as bones should always be handles when wearing protective gloves there should be no problem. Gloves should be worn partly to protect the bones from oils in the skin of hands. If bones have dust on them this should be removed either by dusting or blowing with compressed air in a fume cupboard or near a dust extract, so that the dust does not get ground in to the porous bone surface.

Herbaria sheets: These should always be handled with protective gloves (see insecticide/pesticide section above), and the sheets should always be held horizontally, flat to a work surface. They should never be tapped to line up the edges.

Mould: Many collections can develop mould whenthe atmosphere is too humid, and this cancause problems if inhaled.

Biological hazards: Some objects can harbour dormant diseases such as smallpox and anthrax. This may occur in human and animal remains, blood and manure deposits, wattle and daub, and animal skins which have not been fully processed into leather, as in many ethnographic collections. Freeze-dried and air-dried specimens may provide sources of infection. Although desiccation may inactivate some bacteria and fungi, some are quite resistant, for instance the rabies virus may survive for years if freeze-dried. Some venoms may remain effective even after drying or deep-freezing andsome dried fern spores are carcinogens.

***Allergies*:** Those who suffer from allergies should be aware that certain plant and insect hair and scales can still cause allergic reactions long after specimens have been collected.

***Random products*:** When clearing out cabinets, boxes or drawers, jars, bottles or tubes may be found, sometimes unlabelled (and sometimes mislabelled). These should be assumed to be toxic unless it can be proven otherwise. They should be handled carefully and stored in your safe chemicals cabinet after being documented appropriately. They must be identified and treated appropriately. They cannot simply be disposed of in normal waste bins, all disposals must comply with COSHH regulations. Contact your local conservator or local council for advice.

Storage: Storage accommodation should provide the physical and chemical requirements of materials and containers, e.g. flammables stores, fire-proof cupboards, cabinets made from resistant materials or simply very sturdy shelving for heavy fluid-preserved specimens. Incompatible chemicals must be stored separately. Unstable combinations include: mineral acids and organic solvents (both incompatible with organic peroxides such as resin catalysts); acetone and chloroform; cyanoacrylates and some epoxy resins; and hydrofluoric acid and ammonia. More comprehensive lists of incompatible substances have been produced by Bretherick (1986) and Howie (1986, 1989).

Labelling: The insufficient or inappropriate labelling of material can create hazardous or potentially lethal situations. All substances must be clearly identified, preferably with an indication of any dangerous properties and safety precautions. Labelling should not only be on the containers but on any packaging used for their transportation. All chemical substances should be handled with care. Bottles, particularly Winchesters, should not be carried by the neck but by using an appropriate container that supports them from below.

Stackers and other electronic or manual lifting devices: Two people should be present when these are used; it is good practice to wear hardhats and steel toe-capped boots; there should be no standing or working beneath a raised platform; no standing on a platform at any height; do not exceed the maximum weight; make sure the brake is applied before using the platform; be aware of limbs and fingers getting trapped (amputation is a real risk) so keep them away from the equipment when in motion; make sure loads are centralised and secure on the platform; make sure there is clearance directly above the platform and above the lifting mechanism; and be aware of the moving platform catching shelves and crates especially in store room of fluid/spirit preserved specimens. If batteries need to be charged, do not leave them on charge overnight; make sure charging is in a well-ventilated area; unplug the charger and leave it for five minutes before disconnecting the leads from the battery.

***General advice*:**Undertake risk assessments for handling, packing, moving and/or transporting each sub-collection. Remember that in the majority of cases the level of exposure to toxic materials will be very low. Get specialist help if you suspect you may have radioactive materials or asbestos in your collection. A conservator, curator or other specialist will be able to identify them for you and give advice on measures you can take to minimise risk. Follow Health and Safety Executive guidance at all times. Make sure everyone who comes into contact with the collection follows basic good hygiene practises: Never eat or drink in a collection area; always wash your hands after handling any objects; and wear disposable nitrile gloves to handle any objects where there may be a risk. The removal of items from a natural history storage area should be kept to a minimum: lab coats not only protect clothes but prevent contamination from being carried out of the area of risk and into clean areas such as offices etc – as long as they are left behind in the storage or lab area! This is true of packing materials, bags and boots etc. Be aware of transferring clouds of potentially harmful dust into what are expected to be ‘clean’ areas. Gloves should always be worn when working with specimens, but be in the habit of scrupulously washing your hands when leaving a storage area and certainly before eating as other material may be handled that you expect not to present a hazard but which might have potentially harmful dust on the surface. Repeated exposure to even slight risk is not a risk worth taking.

Make sure people know which objects pose a risk. Identify the objects involved, use a labelling system on the objects and boxes containing them and update your collection data-base. Restrict access to suspect objects and minimise handling and use, until you have sought advice. Make sure that no potentially hazardous objects are accessible to the public in open displays, handling collections or school boxes. Check regulations and get specialist advice as appropriate before disposing of hazardous materials or contaminated packing.

It is a legal requirement for manufacturers to make data sheets available to their customers, giving chemical composition, known health hazards, exposure limits, first aid advice and methods of disposal etc. These should be retained for reference so that they can be referred to when it comes to using the products or packing and moving them.

It is a good idea to create a code of working practice that outlines the safety implications for specific working practices, including: emergency procedures for fires and other accidents; where to get help, including access to a first aide and first aid kit and/or spill kit; the correct use of relevant equipment; hygiene precautions; and any other information that safety dictates, including any special provision for the disabled (including poor eyesight, poor hearing, dyslexia*etc*); It may also be useful to include information on working practices and security (people finding they are suddenly in a locked area with no phone signal is a health and safety risk). A standard form should be issued to all employee or volunteers working on the project outlining all the health and safety issues including the role of personal responsibility for safe working practices. Making this a form that is in duplicate (just two photocopies) and that have to be signed to show that the information has been read and understood focuses the mind of the person reading it and the information is more likely to be absorbed and retained. It can also help the institution avoid claims of negligence.

Where a variety of tasks is undertaken in the same area, it is not sufficient to be familiar only with those hazards associated with the task in hand. Anyone working in such areas should be aware of all of the dangers around them.

Sources of information about hazards in museum collections:

Bretherick, L. 1986. *Handbook of reactive chemical hazards*.Butterworths, London.

Found, C. &Helwig, K. 1995. *The reliability of spot tests for the detection of arsenic and mercury in natural history collections: a case study*. Collection Forum 11, 6-15.

Howie, F.M.P. 1989. *Safety considerations for the geological conservator*. Geological Curator, 4 (7):378-401.

Richards, J. P. 1994. *Health and safety in natural history museums*.In 'Manual of natural history curatorship' (Stansfield, G., Mathias, J., & Reid, G. eds). MGC, London, pp213-231.

Don't Panic: Dealing with Hazardous Materials in Collections, Institute of Conservation, Birmingham Museum & Art Gallery, November 2006. Notes from the meeting are available at: http://www.icon.org.uk/index.php?option=com_content&task=view&id=74&Itemid=

*Fluid preserved collections:*Natural Sciences Collections Association website http://natsca.info/content/fluid-collections

Working with Substances Hazardous to Health. 2009. Health and Safety Executive http://www.collectionslink.org.uk/discover/environmental-control/842-working-with-substances-hazardous-to-health-coshh

Legal requirements:Natural Sciences Collections Association website http://natsca.info/content/policies-legislation

Human remains guidance: http://www.culturalpropertyadvice.gov.uk/public_collections/human_remains

Disposal of hazardous waste including asbestos & radioactive materials: Environment Agency website for information, guidance and registration
http://www.environment-agency.gov.uk/business/topics/waste/32180.aspx

Kadec is an asbestos management company:
http://www.kadec.co.uk/preliminary-asbestos-risk-assessment-checklist.htm
T: 01702 308 438 E: enquiries@kadec.co.uk
365 Hamstel Road, Southend on Sea, Essex, SS2 4LE.

5 Case Study: the Natural Science collections stored at the Museum Resource Centre in Ryegate Road, Colchester.

5.1 The collection

Most of this Natural History collection of approximately 500,000 objects has some documentation directly associated with each of the specimens so it should be considered of relatively high scientific value. Although not Designated, the collections were rated highly in a national context in the SECRU Survey(the Museums Association's Biological Collections UK report) published in 1987. It was listed as being a 'Group 7' collection: 'The most active museums. Very large collections including type specimens.Undertaking wide range of activities including sound scientific work.Providing very good service to the community'. However, this was based partly on criteria such as the number of staff and research, so the department possibly no longer fulfils what is needed to be Group 7. Certainly the collection is specifically relevant to Colchester and north east Essex and remains a unique and irreplaceable record and reference tool to answer queries about the past and current natural history of the area.The collection was built up virtually from scratch from the 1950s onwards and reflects the changes in the flora and fauna over the past 60 plus years and forms a record of local species and biodiversity over this period. The collections include some Victorian material from local collectors Temple (beetles), Blaxhill (butterflies), Mathew (of Mathews Wainscot fame) (lepidoptera) as well as eminent naturalists from elsewhere such as William West, R.D. Weal (beetles) and Yellowly-Watson (minerals). Contemporary collections include the Warner collection (lepidoptera and beetles), Cox (beetles) and the Bowden Diptera collection. Other donations are promised in bequests (J. Firmin, Nigel Cuming). The collection also includes material from Sudbury Museum which was closed. Many of the specimens are vouchers for biological records and publications (e.g. Birds of Essex, Wild flowers of north east Essex, various national distribution atlases, scientific papers etc.).

The geology collection of approximately 10,000 specimens was assessed by the Area Museum Service (AMSSEE) in 1988with the report by Simon Timberlake rating them highly: '(this is) a large and fairly important' collection, 'probably the most important repository of geological material in the county'. 'The Sudbury Museum collection was clearly an important one in its heyday and the geological material was well documented and of good quality. The rescue of the collection by Colchester from its then state of compete neglect is to be thoroughly commended, although what is now needed is a major project to re-curate and catalogue the collection and conserve the specimens and oldlabels. The collection should not really be moved or any part of it used until this work is effected'. In addition the geology collection as a whole is rich in local Pleistocene material from the North Sea (e.g. Dr Bree collection, and recently Les Brand collection) and Clactonian material - some of which is

figured. There is other figured material such as Bree'sziphiid whale rostrum, a PhD collection of Coraline Crag fossils, some very good quality Jurassic fish and some very nice Liassic fossils from Whitby.

Many of the natural history sub-collections are beautifully curated (see the images on the title page of this report) but they would still require a substantial period of work to prepare them for a move, including the necessary repacking into temporary storage media with the appropriate documentation. Some parts of the collection would require additional work such as bagging specimens and labels together so that information is not lost during the move, and some items require basic identification so that they can be documented for the move. There are no specimens that are of such poor quality they should be disposed of. Quite the reverse. Even the most neglected of the sub-collections appears to have material in it quite worthy of scientific study. This is quite rare in a collection of this size. If the collection as it stands was fully documented and the information was available online so that all local stakeholders and researchers further afield knew what the collection contained then it would probably be well used. In addition, there are plenty of projects that volunteers, students and staff could undertake to enhance the collection further: such as scanning and documenting some of the slides and photographs; improving the storage media and documentation for the geology collection; and cataloguing the books, journals and periodicals etc.

The collection is well stored in that only a very small amount of space could be saved in the collections area by getting rid of old cardboard boxes, old empty entomology cabinets and either filling-up or getting rid of the old empty BM cabinets (e.g. G88, G85, G89, G86, G87, G54, G58, G66) or by moving the 'Handling collection' (G84) to the museum where it might be better used. There are a few cabinets that couldn't be opened and assessed: numbers 168, 169 and Osteology 3, and there was no time to see the Natural History collections above the gallery in the church. The collection is not well stored in that many of the wooden cabinets are becoming increasingly difficult to open and close.

5.2 The Museum Resource Centre building

This is a late Victorian industrial building constructed of brick with a slate roof and single-glazed metal windows. Originally a brewery, it has been a warehouse, offices and since the 1970s the Museum Resource Centre; the main administrative building for Colchester Museums (latterly Colchester and Ipswich Museum Service). It is a multi-use building, housing stores of various disciplines plus the natural history and conservation laboratories as well as providing the main office and research space for museum staff.

The Natural History stores are split between two areas: the main collections area being located on the top (3rd) floor of the building with an additional entomology store (Harwood Room) on the 2nd floor. From the store on the top floor of the building there are 58 steps between the collection and the road outside: there is no lift. It has a high pitched roof space, open to the store below and metal windows. Some improvement works were carried out c2005 in an attempt to insulate and seal the ceiling panels, but this was of limited efficacy. Likewise the windows are ill-fitting and are neither air nor insect proof. Light levels are reduced by fabric coverings but again these are not entirely effective and do not prevent insect ingress.

The temperature and humidity suffer from considerable fluctuations. The heating system in the building is not zoned and the building has always been heated for human comfort rather

than collections, which is poor practice where natural history collections are concerned. It is not possible to isolate spaces, so the propensity of the building in winter is to be too hot and thus too dry and conversely, damper in summer. The main pitch of the roof is southward so this likewise exacerbates temperature change. Similarly, the daily cycling of the central heating also means that the daily extremes can exceed the 10% relative humidity change that is the ideal.

The cabinets are a mixture of older plywood constructed carcasses and more recent conservation grade metal units. The older sorts are not adequately sealed, despite best endeavours, and frequent infestations of tobacco beetle and anthrenus affect the herbarium and study skin collections. The herbarium receives a constant cycle of freezing and cleaning and signs of pests are often found. The mammal study skins were recently frozen and repackaged and evidence of moths and beetles were found. The bird study skin collection has signs of pest infestation and is currently being repackaged (sealed into plastic tubing). It is anticipated that this entire collection will be frozen at Ipswich in the summer 2013.

A further problem is that the older cabinets were largely assembled within the store and are increasingly fragile. It is anticipated that they would not provide adequate protection to the collections if moved, and indeed, may potentially be too deteriorated to withstand removal.

Although the environmental conditions provided by this building are clearly not ideal at all for this collection and although the collection is prone to insect infestation due to the nature of the building and the inadequate nature of most of the storage cabinets, the collection should only be moved to different premises if it can be proved beyond all reasonable doubt that the conditions in the new building would be markedly better and that the physical transfer of the specimens from the current stores to the new premises is not going to endanger the specimens. The ideal environmental conditions for this sort of collection are given below, along with a list of 'pros and cons' in regards to moving the collection.

5.3 Packing up the collection for decanting to a new store

Suggested processes to be undertaken

Before the move, the new premises should beinspected and monitored:

- Check all the gutters, storm drains and down pipes etc to make sure they are free of builders' rubble and other material and that they are in good repair and are working.
- Make sure all doors seal well, and all ducts are blocked up that need to be.
- Seal around all the window frames and check any old chimneys are blocked off securely.
- Instigate a robust Integrated Pest Management policy and put up appropriate notices: no food to be eaten in stores, no rubbish to be left in stores, and nothing new goes into the stores without first being quarantined and frozen if necessary.
- Ideally you would already have environmental data from the new premises demonstrating their suitability in regards to temperature, relative humidity and both the daily and seasonal fluctuations of these.

Packing up the collection:

Labelling:

Each cabinet (whether full or empty), each pallet of drawers, each box of drawers and every individual large object destined to be moved out of the original store should have a label attached to it securely that will include a unique bar code identifier. This will require a bar code reader, the software to use it and possibly some training may be required.

Each label could be colour-coded to identify exactly who is authorised to move the object or cabinet it is attached to. For example, a red label could signify that only the curator or member of staff named on the label can move the specimen/box/cabinet (for the entomology cabinets and fluid-preserved specimens, for example); orange/amber labels could signify that any member of staff can move the object; whereas a green label would signify that anyone suitably trained can move the object e.g. a volunteer. A brown label might indicate an empty carcass of a cabinet that a removal company employee can move.

It will not be practical to label every single specimen, nor indeed to log every single one on the database/spreadsheet containing the details of the move. There can be hundreds of beetles or molluscs in a single drawer for instance, so instead a record can be made for each drawer if the contents of the drawer are already known and logged elsewhere. The label on each pallet or cardboard box would list all the drawer numbers on or in that box/pallet – and this information would also be in thespreadsheet.

When moving a drawerful of material, it would be useful to have a printout (on archival paper) put in that drawer in advance, listing the contents, so there is a permanent paper record with the material (useful for the project, and useful thereafter) as labels can fall off/be knocked/rubbed/ripped/washed off the external surfaces of crates and drawers.

Securing the labels: sticky labels with good adhesive will stick to polypropylene crates, but they cannot be relied upon to stick to wooden or cardboard crates securely. Labels for wooden crates and cardboard boxes could be laminated and stapled on, always in the same place, e.g. the top left hand corner of the front side.

Nice old wooden cabinets would be disfigured by stapling: With these, laminate the label, hole-punch the top left corner (not too close to the edge) and tie it securely around the hinge, ensuring that the door will shut properly and no stress is put on the wood around the hinges. If the wood is stressed by this, instead you can staplegun the string or cotton tie to the inside of the cabinet door, with the label left hanging on the outside.

Labels:
I suggest that all labels are printed consistently to a single template, and that there are no handwritten labels. I suggest the following:
On each and every label (at least one per crate, box, cabinet carcassetc) in a consistent and readable format there should be:

- A unique bar code
- If a single specimen, its accession number in addition to the bar code
- A colour coded triangle/ circle/ indicating who is to move the specimen. E.g.:
  - Red = extremely delicate and/or important (e.g. Entomology; fluid-preserved specimens) and it is only to be moved by the named member of staff
  - Amber = any member of staff
  - Green = trained volunteers

    - Brown= storage furniture to be moved by removal company
- Description: e.g. Red Crag Molluscs from Waldringfield.
- Original location (a consistent form such as: store, aisle, bay, cabinet, shelf)
- Temporary location after packing (a consistent form such as: store, aisle, bay, cabinet, shelf)
- Destination location(a consistent form such as: store, aisle, bay, cabinet, shelf)
- If the crate, box or drawer weighs more than 20kg there should be a label advising of this.

Documentation**:**
For each and every specimen or drawer of specimens, the packer would record the above information (i.e. that which is going on the label) on the spreadsheet, and then print from the spreadsheet format an appropriate sticker or label to be laminated.

Other information that would be recorded on the spreadsheet but would not be printed out would be:

- A list of all the specimen accession numbers (not required if moving drawers full of hundreds or molluscs or insects, but required if moving individual specimens from their original storage medium into new storage medium e.g. fluid-preserved specimens in jars being moved from shelves into crates, or bones moved from drawers into boxes etc).
- Who packed the material
- The date the material was packed and the record made
- What digital image numbers are associated with this record (e.g. if a photo is taken before packing
- Conservation issues that have been noted, in the following fields:
    - Presence of pests noted (not necessarily damage, it could be frass or insect remains): description
    - Pest damage noted: description
    - Remedial repairs required: description
    - Other (e.g. jar cracked; fluid needs to be topped up; cigar box split etc)

Data management:
All the spreadsheet data should be backed up on a daily basis from the project laptop to a flash drive which should be handed to single named member of staff responsible for backing it up onto a desktop PC or the main museum system. The principal working copy would be the one on the project laptop. It would be useful if those packing and making the entries could have access to email in the stores so that queries can be raised during the day whilst working.

Thespreadsheetshould be created in a format that will enable the seamless transfer of information onto the museums database at the end of the project.

If a specimen does not have a unique identifying museum number already attached, it will need to have a temporary number. There will need to be a list of unique numbers prefixed with a relevant code ready.

Photography:

Decide how much is photography is required during the packing phase. The existing database may not cope with lots of photos being added so any photos taken may not match up directly with existing records immediately, but it still might be useful to have a separate database of images. You will not have the time to photograph everything individually but you should at least take good, useful photographs in a sensible and consistent consecutive order of every drawer or shelf before it is packed, with existing labels legible and a label stating the location such as 'Fluid collection, cabinet 3, Shelf 2'. This labelling information can be printed in advance, and stuck in the appropriate place before packing commences as it will be useful not just for the photographs but for those packing and documenting the collection.

Moving specimens:
All volunteers and staff should attend a day or half day's manual handling training showing how to lift and move specimens safely. You would be considered negligent if this wasn't done and someone injured themselves. Mechanical handling (trolleys, electric stackers, scissorjack trolleys etc) should always be used where possible.

Doubling the number of people working on the project will not mean that the work will only take half the time, as there will be a limit to the amount of mechanical handling equipment that can be used in a store, and a store may become crowded quickly.

Packing:
As they are packed, specimens should be checked for signs of previous or active pest infestation.

All instances of previous or active pest infestations should be recorded as appropriate on the spreadsheet and dealt with appropriately (e.g. quarantine, freezing etc) as soon as possible.

Glass fronted display cabinets: these should not be moved as they are. They need to be packed in sturdy cardboard boxes, with card or plywood taped over the glass surfaces. They should only be picked up by their base, not by holding on to their sides.

If enough time and resources are available, the move should be used as an opportunity to document all the specimens as thoroughly as possible as they are transferred into temporary storage media, as a certain amount of documentation will be required for the process anyway. As almost all specimens will be handled and documented at some point during the move it would be a wasted opportunity if the objects were moved to the new stores without their records being enhanced.

5.4 Details of packing up and decanting the individual natural history sub-collections at the Ryegate Road stores

The single biggest problem facing this particular project (i.e. moving the contents of the natural history store to another site) is the fact that the store is located at the very top of the building and the building has no lift other than from the ground floor to the first floor. There are 58 steps down to the road.There are only two ways of dealing with this:

1. Hire a temporary external lift, such as is used on building sites, to provide access to the top floor (11.5 m)to decant the main collection and to the 2nd floor to provide access to decant the entomology collection and the library.
   Or,
2. Resign yourselves to the fact that staff and volunteers will have to carry 500,000specimens down 58 steps approximately 1,622 times.

The cost of suitable lifts:

- Formobile scissor-jack lifts for up to 17 metres height see: http://www.facelift.co.uk/hire/scissor-lifts/
- This one should do the job (it goes to 17 metres, but only 12 metres should be needed): http://www.facelift.co.uk/hire/scissor-lifts/skyjack-9250-4x4
- Cost of the above per week (five days) without an operator: £350 + 20% for insurance + £70 transport + one day training course at £170 = £660 (I assume you would need at least 2 weeks = £1,150 (approx.). However, as this is a public space, you will almost certainly need an official operator at approx. £280 a day = £1,400 for 5 days to add to the above (£2,060 for 5 days, or £3,950 for 10 days).
- These scissorjack lifts can be bought new for about £11,000. See:http://www.afi-resale.co.uk/newcherrypickers but generally only go to 9.9 metres.
- They can be bought secondhand from about £2,500. See: http://www.afi-resale.co.uk/cherrypickerforsale/JLG/2646/2004 but generally only go to 9.9 metres.
- The council may already have access to one, or may have alternative methods.
- There will be an additional cost of enlarging the window (and providing a temporary cover for the space) so that large boxes and cabinets can be passed through on to the platform.

If a lift is hired (for specimens and their cabinets, it does not have to carry people), the collection would be packed-up as much as possible in advance (undertaking all appropriate documentation etc – see above) so that the lift is hired for as short a time as possible, keeping costs down. This means that mechanical handling is used as much as possible. This is safest for people and safest for specimens, i.e. best practice.

If a lift is not hired and staff and volunteers are expected to manually carry several thousand specimens down several flights of stairs (58 steps – some just bare concrete) over one and a half thousand times then both they and the specimens are put at great risk from injury and damage. Any resulting legal action, or even just the amount of staff time lost due to sick leave, plus the remedial conservation work required on damaged specimens may well far outweigh the cost of a temporary external lift. Even if specimens are carried down in very small numbers in relatively light packages, staff will not be able to see their feet or hold on to a handrail. The risk of an accident is still high. Of course reducing the amount carried each time immediately increases the number of journeys up and down the stairs required, in itself increasing the risk of an accident. As well as half a million specimens there are 125 cabinet carcasses that will need to be moved from the top of the building to the road outside and a further 28 cabinets from the entomology collection on the second floor. Even when empty most of the cabinet carcasses will be very cumbersome (they are up to 123 x 45 x 188 cm tall) and will require two people to carry them – meaning one person will have to go downstairs backwards which in is unacceptable. Packing up the library and archive will result in a lot of

heavy boxes, even if relatively small boxes are used (bearing in mind that the smaller the box, the greater the number of journeys required).

If a temporary external lift is used, then some of the collection will not even have to be removed from cabinets. This will reduce the amount of time required to prepare for the move as specimens not removed from cabinets will not need extra documentation or the cost of temporary packing media though some will require bagging-up with their labels. This would also expose the specimens to less risk (assuming the lift is safe and moves smoothly) as damage is often done when taking specimens out of cabinets and packing them for a move. This affects only the smallest cabinets in the collection but it includes the most vulnerable material, the entomology collection. If using a lift, the entomology collection in particular could be moved largely one cabinet at a time, without the need for removing the drawers and packing them in separate cardboard boxes – this would reduce the risk of the collection being exposed to vibration, shock and insect infestation as long as a) a good trolley with soft pneumatic wheels is used from the entomology room to the lift and if necessary from the lift to a vehicle and b) as long as the drawers and doors of the cabinets are secured properly and C) that the lift is smooth in its operation.

NB What is being proposed for the Ryegate road building after the collection moves out? If being refurbished and part of that plan is to install a lift that goes all the way to the top floor, this could be done first, then the collections could be moved, removing the expense ofhiring a temporary external lift but bringing forward the expense of building an internal lift.

When the entomology collection was transported to Ipswich and back to be treated for a pest infestation by freezing in 2008 the professional removal company apparently did a good job (J. Bowdrey, pers. Comm) and little damage was done. I recommend that if a removal company is considered for part of this current project then the same people should be approached. The cheapest company should not be used, but the company who understands museum collections the most and who will treat the material accordingly. Money saved on the cheapest company will soon be outweighed by the costs of remedial conservation to repair damage to the collections if they are moved in a less than ideal fashion.

Packing the collections:

Specimens preserved in spirit*(4 cabinets)*

These specimens will need to be assessed individually and topped-up as required before they are moved, to reduce the chances of damage. It is very easy to try to move too many at once, and the heavier the box, the greater the likelihood of accidents. There are over a thousand Jars, requiring approximately 70 polypropylene crates (similar to some already used - see image below -but many will have to be deeper). These plastic crates should be used rather than cardboard as they are stronger and will contain any spillages if accidents occur. They can remain part of the new permanent storage media, containing any spills. For moving out of the store and for transportation, Plastazote foam should be used to wedge between all the jars to prevent sliding, knocking and to reduce vibration. Approximately 80 journeys down the stairs would be required.

Botany*(12 cabinets, plus 52 boxes of galls, lichen and mosses)*

Herbaria cabinets x 12, each with 18 shelves of herbaria folders. These Individual shelves should be packed in suitable sturdy acid-free boxes 48 x 30 x 15cm high, of which 216 are required. The folders should be handled only by trained staff or volunteers wearing appropriate Personal Protective Equipment e.g. disposable gloves and dust masks (due to old pesticides used). These folders and their boxes must be kept flat. These smallish boxes could be put together in larger boxes so that about 6 are carried at a time. About 36 would be needed (about 71 x 48 x 45 cm high), requiring 36 journeys down the stairs.

On top of some cabinets are dozens of small boxes of lichens, moss and galls etc. These need to be gathered together and put into larger boxes. They will require about 25 journeys down the stairs.

In the small wooden cabinets are a further 20 drawers of plants & fungi etc., requiring a further 20 journeys down the stairs if the lift is not used to move the cabinets.

Skins

Skins in wooden drawers (140 drawers, 7 cabinets of 20). These drawers will need to be removed from cabinet carcasses and boxed-up in sturdy cardboard boxes, making sure the boxes do not get too heavy (roughly 5 drawers per box(requiring abox to take a block of 5 drawers 44 x 69 x 58 cm high)) meaning 28large boxes are required. First, acid free tissue will need to be scrunched and deployed appropriately (approximately 15 sheets per drawer) to stop the skins sliding around during handling and transport as they are in order within these drawers (see images below).

Flat mammal skins: eleven large flat sturdy boxes (approx. 45 x 120 x 25 cm high) will need to be sourced to move these safely.

Bird skins: ten cabinets of 8 large drawers each. The drawers are very large, and their contents are mostly very proud of the drawer depth. I recommend that all the drawers are labelled permanently first (i.e. cabinet H drawer 1, of ‘H1’). Then, remove the drawers from the cabinet and place on the floor to the rear of the store out of the way. Then, move the empty cabinet on to the scissor-jack trolley, lift the cabinet down (or up) to a good working height and replace all the drawers in the right order. Take the full cabinet to the lift and slide it in.If a lift isn’t being used, there is a problem. These drawers are 115 cm wide, 60 deep and

about 10cm high. They will have to be moved one at a time down the stairs to be put in the empty carcass waiting in a van. That will be 80 separate journeys down the stairs for this sub-collection alone, with very wide drawers that preclude seeing much of the steps, and 120 journeys in total for all the skins.

Osteology*(9 cabinets)*

This collection is well curated in a way that means very little has to be done to prepare it for the move. The outside of every cardboard box should be labelled with its permanent storage location such as Ost7 shelf 1 or Ost 7/1 etc. The shelves themselves should also be numbered first, to avoid confusion (some people number from the bottom, some from the top). Put all the smaller and medium sized boxes into larger boxes. This will mean fewer journeys down the stairs if they are used, and also reduce damage to specimens as all these boxes have lids and if the boxes aren't picked up carefully the lids slide, leading to boxes being dropped. The smallest of the mounted skeletons should be put together in one box. The largest skeletons should be moved as they are, very, very carefully. Any vibration or 'bounce' of the skeleton inside the Perspex box will do quite a bit of damage. It is best not to pack it up but to be able to see how the skeleton responds to being moved. The contents of the eightmetal osteology cabinets will require about 100 journeys down the stairs, even if the smaller boxes are boxed-up together into larger boxes, plus manhandling the very large metal cabinets down the stairs. There are 22 drawers of osteology in the smaller wooden cabinets, each of which have contents deeper than the drawers so they cannot be stacked. If the lift is not used to move

full cabinets, this will necessitate 22 journeys down the stairs (122 journeys down the stairs in total for this sub-collection).

Molluscs & othermarine invertebrates

4 cabinets of approximately 90 drawers. Some baggingof labels with specimens is required. Requires 90 journeys down the stairs.

Above left: well bagged molluscs where labels are contained with specimens. Above right: molluscs and labels in small card trays that will require bagging-up to preserve data.

Above: marine invertebrates already well boxed and labelled.

Geology *(minerals 8 cabinets; fossils 14 cabinets, rocks 10 cabinets)*

There is only one specimen in this collection that I know is radioactive, and it is in a lead box (but possibly imperfectly sealed). I have not seen any records so I don't know how radioactive it is, and I don't know if there are any other radioactive specimens. Read the section above about radioactive material and check your database to see if you have any of the minerals listed that might be radioactive. Then, do as this section recommends and have your specimen in lead checked, and the rest of the collection at the same time and take appropriate action.

Regarding your two drawers of asbestos specimens, first check your database against the list above for all asbestos specimens and asbestos-like material. Follow the health and safety guidelines above, using appropriately trained personnel. Whatever you do, do not approach the specimens without disposable gloves and good dustmasks, or without specific training.

The geology drawers are small but heavy, and their contents are mostly very proud of the drawer depth (see images below). I recommend that all the drawers are labelled permanently first if they aren't already (i.e. G10/1, G10/2 etc). Then, remove the drawers from the cabinet and place them on the floor to the rear of the store out of the way. Then, move the empty cabinet on to the scissor-jack trolley, lift the cabinet down (or up) to a good working height and replace all the drawers in the right order. Take the full cabinet to the lift and slide it in. Repeat the process when transferring the cabinet into a lorry or van, and again at the other end in the new stores.

Some drawers with small specimens sitting on labels or labelled card trays will need bagging-up in their card trays to keep the label and specimen together to avoid any muddling if contents of the drawer are dropped or knocked en route. All hazardous materials (arsenic, asbestos, lead etc) should be identified and bagged-up in advance with warning labels whilst wearing suitable PPE (gloves and dust mask).

If each drawer has to be carried down the stairs individually, this would require about 463 journeys. However, some drawers will be too heavy and contents will need to be put into separate drawers temporarily so add about 20 more journeys. There are also some heavy slabs on top of the cabinets, will be very difficult to move these downstairs without a lift with current H&S guidelines.

The six metal Bisley cabinets (G73, G74, G75, G76, G77, G78) can each be moved with their drawers in place after they have been tied shut with cotton straps running through their handles and behind the whole cabinet to stop them sliding out (6 journeys down the stairs if light enough). However, most of the drawers require the bagging-up of specimens with their labels first.

Geology cabinets. On the left you can see some specimens are taller than the drawers are deep.

Eggs

Apparently a 'LUMeN' placement student will be working on the egg collection for eight weeks over the summer (2013), using Douglas Russell's guidelines for classifying egg collections to rationalise the specimens and/or send material to the NHM's Bird Section at Tring at the end of the year. However, the following advice is given in case this does not happen or in case the majority of the material stays in the collection. There are five small cabinets of eggs. The eggs and their labels need to be bagged-up in their card trays so that data does not become disassociated. This would take a few days. A couple of small donated collection in shoes boxes and wooden trays should either be curated properly or be destroyed if not worth keeping. Once the bagging is done, and the required documentation and labelling of the cabinets, these can be moved as they are with the scissor-jack trolley to the lift. If there is no lift, then drawers will have to be labelled and removed and placed into cardboard boxes, with sheets of plywood between each one (each sheet bigger than the drawers to stop the drawers crushing eggs in the drawers below). This collection would require about 12 journeys down the stairs.

Entomology

This collection is housed separately with stricter IPM measures as the specimens are so vulnerable to pest infestation. This will have to be reflected in the design of the new stores. Most of the collection is housed in smallish wooden cabinets. If these are not too heavy it is best that they are moved as they are without removing the drawers. This saves over-handling and exposing the contents of the drawers to more shock than necessary. There are 28 wooden cabinets that can be treated in this way. They just need documenting, labelling, and taping-up and locking. If they are too heavy to lift, half the drawers may be taken out, or all.

The larger wooden cabinets and the large grey metal cabinets will have to have some or all of their contents decanted into two or more sturdy cardboard boxes per each cabinet. Between each glazed drawer there should be a thin sheet of plywood to protect the glass from damage. The cardboard boxes must not be hugely bigger than the drawers. Any spare room should be packed with bubble wrap to stop the contents from moving. Approximately 40 to 90 cardboard boxes needed. Up to 120 journeys would be needed down the stairs. The entomology cabinets and their contents must be transported directly from their current store to the new stores where there will already be a strict IPM policy in place, without any intermediate stage elsewhere unless they are taken for freezing specifically to eradicate pests. In which case as soon as they have been frozen they must be transported to their new stores.

Slides, photos and glass plate negatives

The contents of the three large cabinets of colour slides, photos and glass plate negatives will need to be packed up very carefully into sturdy cardboard boxes. The boxes should not be too big or they will get heavy quickly. If possible, the contents of each shelf would be packed up as a single box, to keep their current association and documentation straightforward. Care must be taken not to tip the plastic boxes holding the slides or they will fall out. 18 boxes will be needed, approximately 55 x 40 x 21 cm high. The filing cabinet containing colour slides in sleeves: The contents of each drawer should be packed in separate, well-labelled boxes. There are two more cardboard boxes of colour slides on top of cabinet E. In total, 24 journeys down the stairs are required.

Miscellaneous material in the main stores

On top of the various cabinets are old entomology boxes, glazed taxidermy birds, stuffed birds on branches, old taxidermy and packing materials and old cabinets to be disposed of. A selection of large study cardboard boxes will be required, as well as hundreds of sheets of acid free tissue and a lot of bubble wrap. All the spare drawers for cabinets will need to be put in large cardboard boxes to be carried safely down the stairs several at a time. The large glazed specimens (including the glass dome) and the wasps nest may require purpose-made wooden crates. All these items require about 105 journeys down the stairs.

Library on the 3rd floor

It is assumed that the library will move with the collections, as the books will be needed to work on the collections effectively. There are 88 shelves each 22 cm deep, 28 high and 90 long, so 88 boxes ofapproximately44 x 28 x 45 cm will be needed if a lift is used, or if using the stairs, 176 boxes about half this size (the boxes must be smaller and lighter if they are to be carried down the stairs). The shelving will have to be labelled first, and the boxes packed in order with the boxes labelled with the shelf number so they can be put in the same order again at the other end. The shelving will have to be moved as well – this will have to be dismantled carefully and may require a carpenter to put it back together at the new site. Plus on top of cabinets in the store on the top floor, there are more books requiring about another 36 boxes. Approximately 230 journeys down the stairs if the shelves themselves are included.

Lab facility

The stores on the 3rd floor currently have a lab facility adjacent to them. This space is used for laying specimens out on benches so they can be studied, documented and photographed. It is also a space where specimens can be cleaned, conserved and repaired. Enough space is needed for people to be working on different projects at the same time, as well as for the storage of conservation tools, equipment (microscopes, videomicroscope and monitor etc) and materials and packing material. Hot and cold running water is required with a sink and draining board as well as plenty of electrical sockets. At least one of the freezerswill be required at the new facility so an appropriate space near an electrical socket will be needed. Approximately 150 journeys down the stairs would be needed to decant the lab area.

5.5Facilities required at the new stores

The collection as currently stored on the top floor of the building is rather densely packed. Cabinets are stacked one on top of another for historical issues regarding lack of space, without much regard for ergonomics or health and safety. Access to some cabinets is very difficult. The store is too full, which compromises both safe storagefor specimens and the safety of staff and also impedes access to collections. Therefore any new premises should not merely replicate the existing volume as this is demonstrably too small, but should provide more volume and better cabinets with some mechanical handling devices such as a basic scissor-jack trolley.

As well as providing at least as much storage space as the collection currently takes up (including the main store, the entomology collection and the library) and preferably more, the new stores must also provide space for lab/work area facilities of at least the same quality and space currently used, so that the collections can be maintained properly and studied. A fume cupboard will need to be installed, and adequate plumbing (hot and cold taps) with a large lab sink. Presumably the benches, cabinets, tools and equipment will be transferred from the existing lab, along with at least one freezer.The new accommodation would also need to take in the material from the store at the Natural History Museum (e.g. mounted taxidermy) which were not assessed but is apparently in substandard conditions.

The minimum footprint required for all the above is xxxsqm for the collections and library, and YYY sqm for the lab and work space (Emma / Sophie. Enter your figures here re the msq required).

Many of the very old wooden cabinets in the current natural history store are inadequate (doors cannot be moved etc) and may not withstand the move to new stores. Therefore an appropriate decision needs to be made very soon about the storage media to be used in the new stores.

5.6Conclusions

To move a natural history collection of this size – even from a simple ground floor store - is no simple task. Great care and time has to be taken in documenting and packing the collection appropriately in advance to ensure the move is undertaken safely, minimising all

risks to staff, specimens and data. The risks to people can be significant and long-term if planning is inadequate and proper precautions are not taken. Even if the collection was moving into ideal new storage facilities with perfect environmental conditions and plenty of pest-free space and new storage furniture, great damage can be done if specimens are not packed carefully in a consistent and appropriate manner or if the appropriate documentation and labelling is not undertaken before the move.

The collection on the top floor of the Ryegate Road stores in Colchester has unique complicating factors relating to the lack of a lift. Risking over 1,600 journeys down the stairs while carrying boxes full of unusually fragile and often heavy specimens (some of which will have health and safety implications if dropped!) plus all the cabinet carcasses would be quite an undertaking. Using an external temporary lift also poses its own health and safety, logistical and cost issues but should be a serious consideration to cut down on the risks to staff.

Whilst the current environmental conditions of the Ryegate Road stores are very much less than satisfactory with perennial pest problems and with temperature and humidity levels fluctuating greatly, the benefits to the collection of moving it to new premises have to be weighed against the risks involved in physically moving the collection, and the risks that may be posed by the new stores.Unfortunately, at this point an alternative building to the Ryegate Road stores has not been identified so it is impossible to come to a conclusion about the benefits or risks to the collection or to staff of such a move.